GILMORE

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F & F ASSOCIATES
ENGINEERING REPRESENTATIVES
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Cove, NY 11542
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CAUTION

The dimensions shown in this catalog should not be used for installation drawings. Toleranced current outline drawings will be supplied upon request when orders are received.

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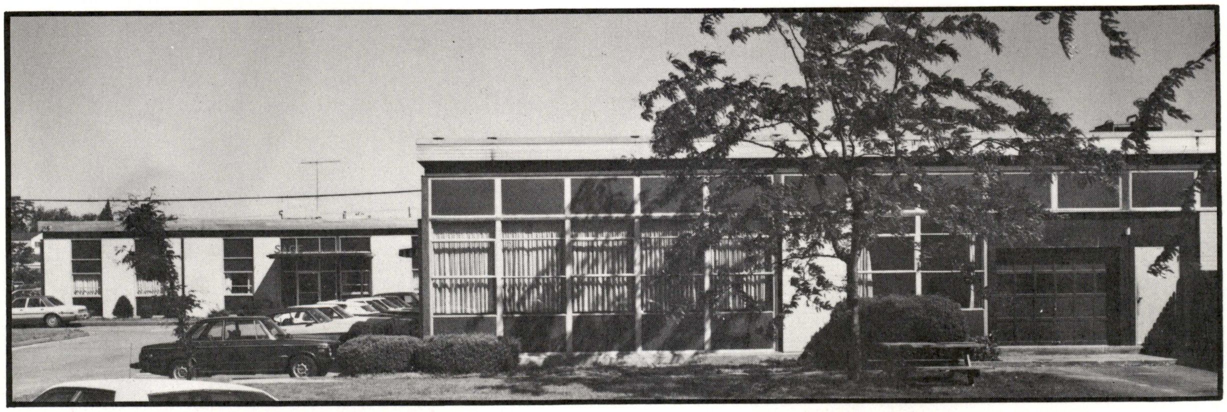
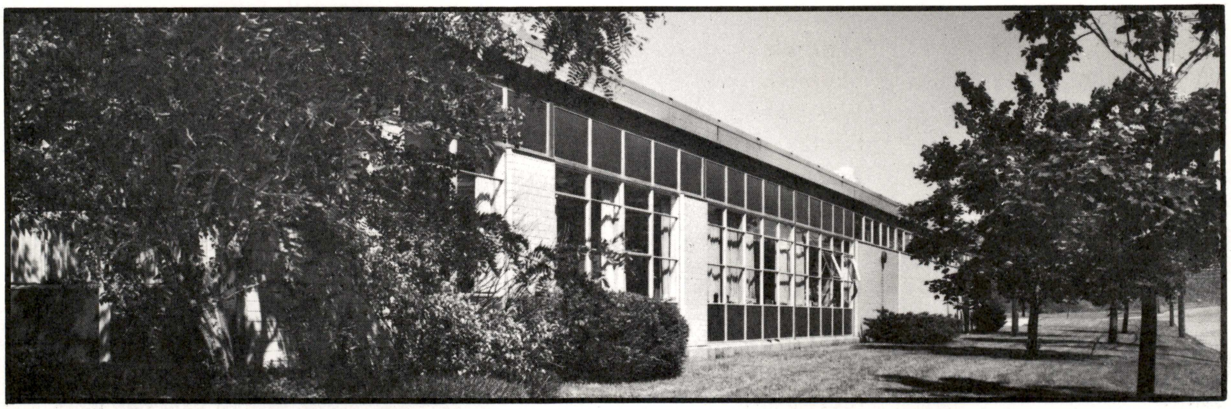
INTRODUCTION





GENERAL

Since its formation in January of 1955, Sage Laboratories has concentrated on advanced applications of microwave technology. The Company manufactures a broad range of components, assemblies, amplifiers and instruments meeting microwave requirements from DC through 50 GHz.

Sage products are used in most military and aerospace systems requiring microwave detection, counter-detection, navigation, or communications. Projects have included such high reliability programs as Gemini, Apollo, Titan II, Polaris, LM and many others. (See listing overleaf)

INTRODUCTION (Continued)

ENGINEERING

Sage Laboratories has completed nearly 2000 contract engineering programs to date. Previous catalogs published by the Company have not reflected this capability. Our catalogs have been restricted largely to standard products, while our engineering capabilities have been demonstrated via separate brochures.

This catalog places equal emphasis on standard products and our custom engineering capabilities. We have included as many specific examples of custom-engineered designs as space allows. We urge you to peruse these sections, for there may be designs already developed which closely approach your current needs. Even if you do not see anything close to what you need, we suggest that you contact our Engineering Department. For every custom design which you see within these pages, there are many more which we simply could not fit.

QUALITY ASSURANCE

Perhaps the best way to demonstrate the capabilities of Sage Laboratories in high reliability and quality assurance is to list some of the key programs and customers served over the years.

SPACECRAFT PROGRAMS	CUSTOMERS
Infrared Astronomical Satellite (IRAS)	Jet Propulsion Labs
777	TRW
TDRSS	TRW
LEM	Motorola
Apollo	Motorola
Viking	Motorola
Gemini	Westinghouse
Mercury	Bendix
Dynasoar	Boeing
Pioneer	Ford Aerospace
INTELSAT V	Ford Aerospace
Surveyor	Hughes
Telstar	(Classified)
Ranger	(Classified)
Advent	(Classified)
Saturn	(Classified)
& others	

MISSILE & AIRCRAFT PROGRAMS	CUSTOMERS
Minuteman	Boeing
SRAM	Boeing
AWACS	Boeing
Giant Patriot	Boeing
Titan II and III	Martin
Agena	Lockheed
C-5A	Lockheed
F14	Hughes
F15	Hughes
Roland	Hughes
F111	General Electric
E-2C	General Electric
B1	General Electric
Polaris	General Dynamics
AEGIS	RCA
EF-111A	Grumman
F15	Loral Electronics
& others	

These and many other high reliability projects completed by Sage Laboratories have included qualification testing, reliability testing, and extensive data requirements including reliability analysis and prediction. Our Quality Assurance personnel have extensive experience in design reviews, configuration control, traceability, material/parts/processes programs, and failure mode and effects analysis. The frequent quality surveys conducted by our customers have, without exception, resulted in approved status to the requirements of MIL-Q-9858, MIL-I-45208, and NASA NHB-5300.4. Our capability, integrity, and reputation for thoroughness (in a timely manner) have resulted in customer awards for quality and workmanship, as well as awards from the Small Business Administration based on nominations by our customers.

INTRODUCTION (Continued)

Reliability Philosophy. There are many prevailing definitions of reliability. Sage Laboratories defines reliability as a characteristic which can be built into a product via deliberate control in all phases of conception, design, manufacture, and field usage. We can achieve satisfactory reliability only after our engineers understand the function to be performed by the equipment, the operating environment, and human engineering factors relating to operating personnel. Given proper consideration of all these factors, the most effective design can be provided, and reliability can be optimized.

Reliability and maintainability must both be optimized if the utility of the equipment is to be optimized. Techniques employed by Sage Laboratories toward this end include reliability and maintainability prediction, failure mode and effect analysis, test and demonstration plans, design review, and quality assurance. These in turn are related to operational considerations defined by the total program concept. These considerations include design trade-offs, cost/operational effectiveness studies, logistics, and other related elements. Our reliability and maintainability programs are comprehensively planned to provide successful implementation of our products into our customers' systems.

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RELIABILITY OF SAGE COMPONENTS

Sage products may be categorized in three major groups for a discussion of reliability,—*passive, dynamic* and *active* element microwave components. Until recently, microwave components have been classified as "low population parts" for which relatively few failure rate data have been accumulated. MIL-HDBK-217B, on page 2-13-2, lists failure rates for microwave elements with fixed elements and with variable elements.

Part Type	**Average Failure Rate (Failures/10^6 hours)**
Microwave Elements	
Fixed Elements	Negligable (less than 0.01)
Directional Couplers	
Fixed Stubs	
Cavities	
Variable Elements	
Tuned Stubs	
Tuned Cavities	0.10

Dynamic components, such as switches and rotary joints, by definition will have a higher failure rate which must be established based on rate of operation (or RPM), operating environment, "on time," stress ratios, bearing loading, the quantity of connectors and associated circuitry if applicable.

Phase shifters may be classified as "variable elements" unless the tuning mechanism is positively locked upon final tuning, at which time it could be classified as a fixed element, with the associated improvement in failure rate.

Microwave mixers may be classified as fixed elements; however, the failure rates of the diodes utilized within the mixer must be added to obtain the total operational failure rate, less environmental factor (formerly part application "K" factor—see MIL-HDBK-217B, page 2.1.7-9)

The failure rate of active microwave components such as amplifiers must be calculated based on parts content, stress ratios, the level of screening performed on parts and environmental factors.

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COAXIAL VARIABLE PHASE-SHIFTERS & LINE-STRETCHERS

CONTENTS OF THIS SECTION **PAGE**

A Selection Guide **5**
Custom Engineering Capabilities **6-7**
Standard Products **8-13**
Application Notes **14**

A SELECTION GUIDE

Sage Laboratories offers several families of continuously variable mechanical phase-shifters and line-stretchers. Compared with solid state phase-shifters, these mechanical designs have the advantage of combining high stability, broad bandwidth, and high power handling capability. The power ratings of these units are typically equivalent to those of the connectors. All designs shown on the following pages are 50-ohm matched impedance devices.

Our most extensive family of phase-shifters (Models 6501-6508) uses coaxial construction with single or multiple trombones. The trombone design eliminates relative motion of input and output connectors. The low frequency performance of these designs is limited only by the physical size required for a given amount of phase-shift. To avoid excess loss and VSWR, the higher frequency models use single trombones and minimum length, consistent with the given phase-shift requirement. Special versions of the 6501-6508 family have been supplied with dial indicators or digital read-out knobs to permit accurate manual resetting of the phase-shift. Other units from this family have been used successfully by customers in servo-driven applications.

Models 6509 and 6510 are single trombone, high performance units which use a slab line construction featuring only one pair of sliding contacts.

The following section highlights a number of custom-engineered designs, which will give you an idea of the capabilities which we can bring to bear on your needs. The section after that describes our standard phase-shifters, all of which are available within 60 days or less.

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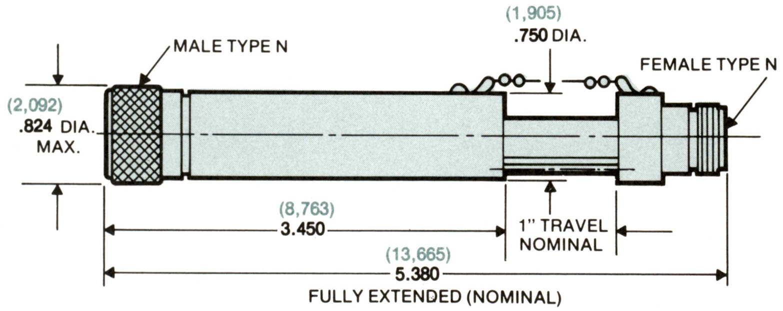
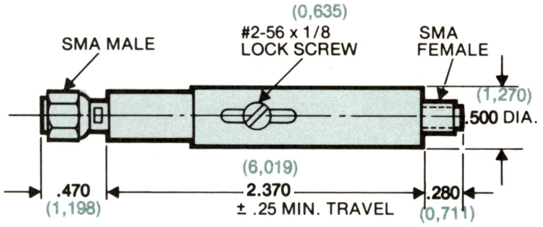
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL LINE-STRETCHERS

Shown on this page is a family of line-stretchers designed for in-line trimming of small amounts of phase-shift. These designs use coaxial construction with matched impedances.


(1,905)
.750 DIA.
MALE TYPE N
FEMALE TYPE N
(2,092)
.824 DIA.
MAX.
(8,763)
3.450
1" TRAVEL
NOMINAL
(13,665)
5.380
FULLY EXTENDED (NOMINAL)

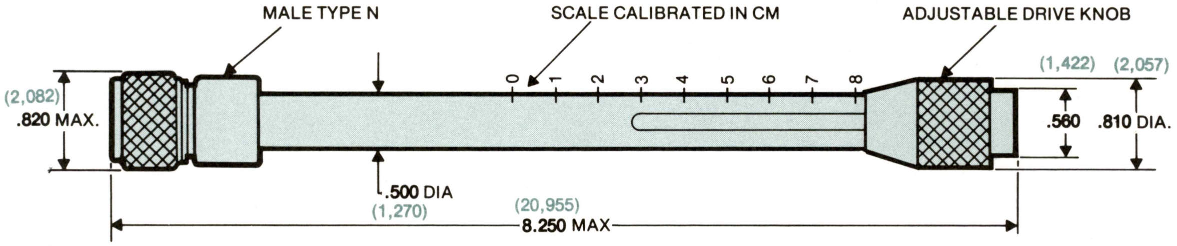
The 597B matched impedance line stretcher is representative of designs suitable for use with N-size connectors or cables.

Frequency Range: DC-12.4 GHz
VSWR: 1.2 max DC-2 GHz
1.25 typ. 2-4 GHz
1.4 typ. 4-12.4 GHz
Phase-Shift: 30°/GHz
Insertion Loss: 0.2 dB typical at 12.4 GHz


(0,635)
#2-56 x 1/8
LOCK SCREW
SMA MALE
SMA
FEMALE
(1,270)
.500 DIA.
.470
(1,198)
(6,019)
2.370
± .25 MIN. TRAVEL
.280
(0,711)

The FS580 matched impedance line-stretcher is an SMA unit with 0.5-inch travel.

Frequency Range: DC-18 GHz
VSWR: 1 + 0.1 x frequency (GHz) typical
Phase Shift: 15°/GHz
Insertion Loss: 0.1 x frequency (GHz) - typical, dB

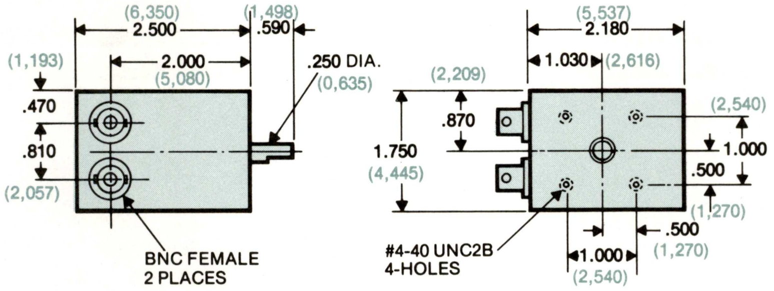

MALE TYPE N
SCALE CALIBRATED IN CM
ADJUSTABLE DRIVE KNOB
0
1
2
3
4
5
6
7
8
(2,082)
.820 MAX.
(1,422)
(2,057)
.560
.810 DIA.
.500 DIA
(1,270)
(20,955)
8.250 MAX

The 635 design represents a different category of tuning device, basically a sliding open circuit. Pairs are available with gang-tuning. In this configuration, they can be connected to a hybrid to provide a variable phase-shift. The advantages of a movable open circuit over a movable short circuit are that higher Q can be achieved, and it is also a DC block (a useful feature in some applications).

Frequency Range: DC-12.4 GHz

Travel: 8 centimeters minimum

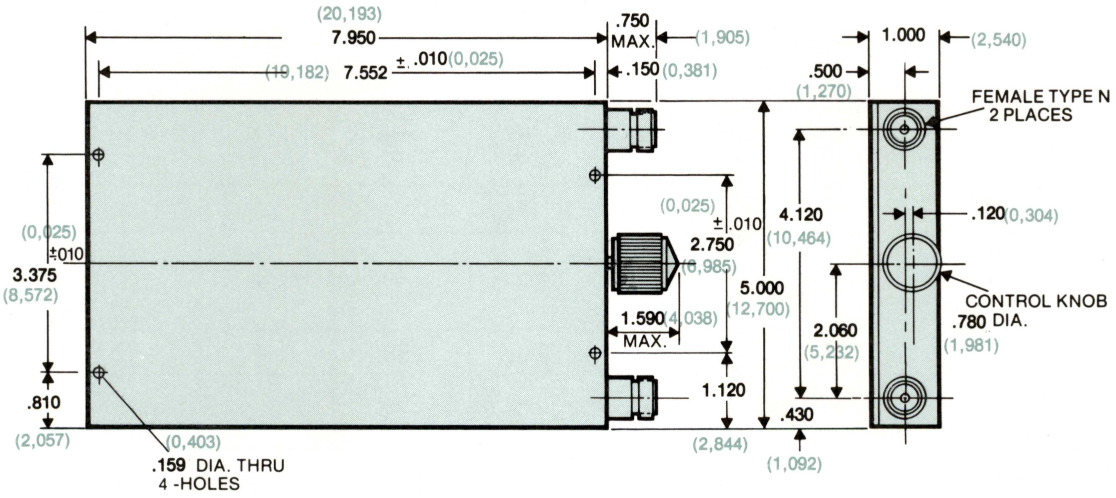
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL VARIABLE PHASE-SHIFTERS



(6,350)
2.500
(1,498)
.590
(1,193)
2.000
(5,080)
.250 DIA.
(0,635)
.470
.810
(2,057)
BNC FEMALE
2 PLACES
(5,537)
2.180
1.030
(2,616)
(2,209)
.870
1.750
(4,445)
(2,540)
1.000
.500
(1,270)
.500
(1,270)
1.000
(2,540)
#4-40 UNC2B
4-HOLES

The FS1783 is a rotating coil goniometer design which is suitable for narrow bands at intermediate frequencies, where its relatively high insertion loss can be tolerated. Its advantages include infinite travel and long term stability.

Type:	continuously variable goniometer phase-shifter
Frequency:	42 MHz
3-dB Bandwidth:	10 MHz, typical
Insertion Loss:	23 dB, typical
VSWR:	3.0 maximum



(20,193)
7.950
(19,182) 7.552 ± .010(0,025)
.750
MAX.
(1,905)
.150 (0,381)
1.000
(2,540)
.500
(1,270)
FEMALE TYPE N
2 PLACES
(0,025)
±.010
3.375
(8,572)
.810
(2,057)
(0,025)
±.010
2.750
(6,985)
4.120
(10,464)
5.000
(12,700)
.120(0,304)
1.590(4,038)
MAX.
2.060
(5,232)
CONTROL KNOB
.780 DIA.
(1,981)
1.120
(2,844)
.430
(1,092)
(0,403)
.159 DIA. THRU
4 -HOLES

In the FS1784 design, a multiple trombone stripline construction is used to provide increased phase-shift in a compact package.

Frequency Range:	DC-500 MHz
VSWR:	1.2 maximum
Insertion Loss:	1 dB maximum
Phase-shift:	900°/GHz 14°/GHz/shaft turn 64 turns stop-to-stop

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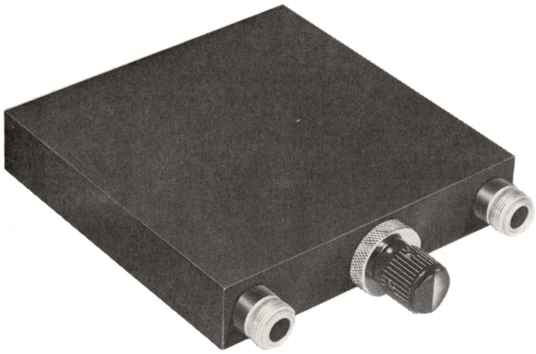
COAXIAL VARIABLE PHASE-SHIFTERS (MULTIPLE TROMBONE TYPE) COVERING DC-8 GHz IN 6 BANDS

FEATURES

- 6 models covering DC-8000 MHz
- precise manual controls can be locked in at any point in the band
- integrated nomographs calibrated in electrical degrees vs. frequency
- all models feature multiple trombone structures



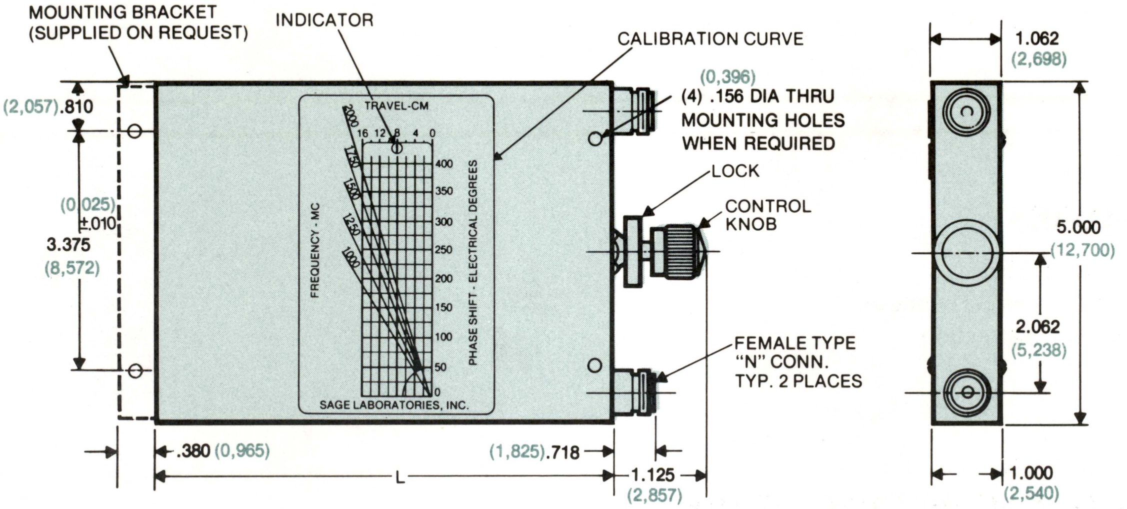
ELECTRICAL SPECIFICATIONS

PARAMETERS	MODEL 6501	MODEL 6502	MODEL 6503	MODEL 6504	MODEL 6505	MODEL 6506
Frequency Range (GHz)	DC-.25	DC-.50	DC-1.0	DC-2.0	DC-4.0	DC-8.0
Typical Insertion Phase at Minimum Phase Setting (Degrees/GHz)	950	950	950	790	790	450
Phase-Shift (Degrees/GHz)	288	288	288	192	192	96
Phase-Shift (Degrees/GHz/shaft-turn)	5.72	5.72	5.72	5.72	5.72	1.91
Phase-Shift (Degrees at max. Frequency)	72	144	288	384	768	768
Maximum VSWR	1.15	1.15	1.25	1.25	1.5	2.0
Maximum Insertion Loss (dB)	0.1	0.2	0.3	0.3	0.5	1.0
Average Power at Maximum Frequency (Watts)*	700	500	350	250	180	100

*Derate average power 50% if phase is adjusted with power applied.
Derate average power linearly with temperature above 50°C to 50% at 100°C.
(Operating temperature range is -55°C to +100°C)
Peak power rating for above units is 2.5 KW at sea level, 25°C.

COAXIAL VARIABLE PHASE-SHIFTERS (MULTIPLE TROMBONE TYPE)

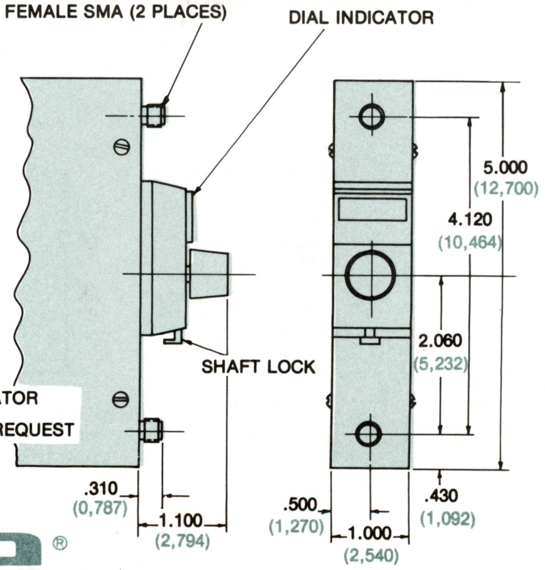
MECHANICAL DATA


MOUNTING BRACKET
(SUPPLIED ON REQUEST)
INDICATOR
CALIBRATION CURVE
1.062
(2,698)
(0,396)
(4) .156 DIA THRU
MOUNTING HOLES
WHEN REQUIRED
LOCK
CONTROL
KNOB
(2,057).810
(0.025)
±.010
3.375
(8,572)
TRAVEL-CM
16 12 8 4 0
2000
1750
1500
1250
1000
FREQUENCY - MC
PHASE SHIFT - ELECTRICAL DEGREES
400
350
300
250
200
150
100
50
0
SAGE LABORATORIES, INC.
5.000
(12,700)
2.062
(5,238)
FEMALE TYPE
"N" CONN.
TYP. 2 PLACES
.380 (0,965)
(1,825).718
L
1.125
(2,857)
1.000
(2,540)

MODEL NUMBER	FREQUENCY RANGE (GHz)	FEMALE CONNECTOR TYPE	LENGTH (L) x HEIGHT INCHES (CM)	APPROXIMATE SHAFT TURNS (STOP TO STOP)
6501	DC-.25	N	6.55 x 1.00 (16,637 x 2,540)	50
6502	DC-.50	N	6.55 x 1.00 (16,637 x 2,540)	50
6503	DC-1.0	N	6.55 x 1.00 (16,637 x 2,540)	50
6504	DC-2.0	N	4.92 x 1.00 (12,496 x 2,540)	34
6505	DC-4.0	N	4.92 x 1.00 (12,496 x 2,540)	34
6506	DC-8.0	N	6.55 x 1.00 (16,637 x 2,540)	50

MATERIALS & FINISHES

- Fabricated in aluminum & brass
- Cases black anodized
- All other metals silver-plated & rhodium-flashed
- All SAGELINE materials & finishes to Government specs


FEMALE SMA (2 PLACES)
DIAL INDICATOR
5.000
(12,700)
4.120
(10,464)
2.060
(5,232)
SHAFT LOCK
.310
(0,787)
1.100
(2,794)
.500
(1,270)
1.000
(2,540)
.430
(1,092)

OPTIONS: SMA CONNECTORS AND/OR DIAL INDICATOR
(SPECTROL MODEL 15-2-11) OPTIONS QUOTED ON REQUEST

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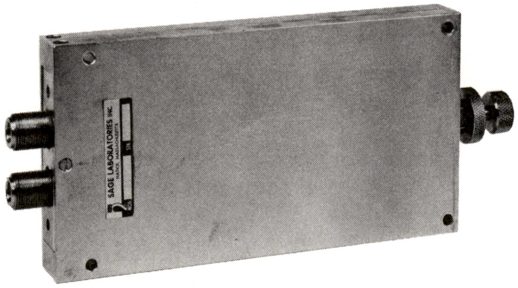
MODEL 6507 COAXIAL VARIABLE PHASE-SHIFTER (COVERS DC-10.5 GHz)

FEATURES

- DC-10.5 GHz
- type "N" female connectors
- rugged construction

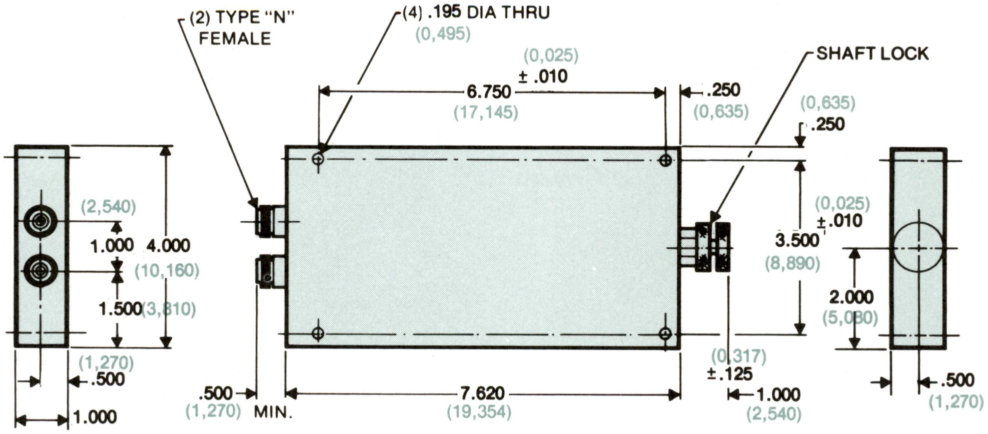


ELECTRICAL SPECIFICATIONS

Frequency Range	DC-10.5 GHz
Typical Insertion Phase at Minimum Phase Setting	300 Degrees/GHz
Phase-Shift (Degrees/GHz)	72
Phase-Shift (Degrees/GHz/Shaft-turn)	1.91
Phase-Shift (Degrees at Maximum Frequency)	756
Maximum VSWR	1.35 DC-8 GHz ...... 1.50 8-10.5 GHz
Maximum Insertion Loss	0.35 dB
Average Power at Maximum Frequency	100 Watts*
Peak Power at Sea Level, 25°C	2.5 KW
Operating Temperature Range	-55°C to +100°C

* Derate average power 50% if phase is adjusted with power applied.
Derate average power linearly with temperature above 50°C to 50% at 100°C.

MECHANICAL DATA


(2) TYPE "N" FEMALE
(4) .195 DIA THRU (0,495)
(0,025) ± .010
6.750 (17,145)
.250 (0,635)
SHAFT LOCK
(0,635) .250
(2,540)
1.000
4.000
(10,160)
1.500 (3,810)
(1,270) .500
1.000
.500 (1,270) MIN.
7.620 (19,354)
(0,025) ±.010
3.500 (8,890)
2.000 (5,080)
(0,317) ±.125
1.000 (2,540)
.500 (1,270)

MATERIALS & FINISHES

Cases silver-plated, rhodium-flashed & painted Sage Hammertone Green	All other metals silver-plated & gold-flashed All SAGELINE materials & finishes to Govt. specs.

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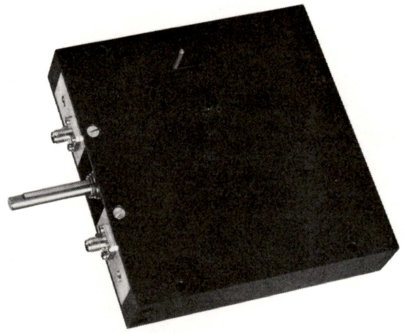
MODEL 6508 COAXIAL VARIABLE PHASE-SHIFTER (COVERS DC-16.5 GHz)

FEATURES

- DC-16.5 GHz
- SMA connectors
- rugged construction

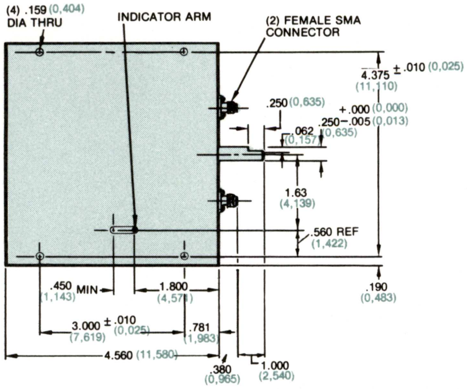


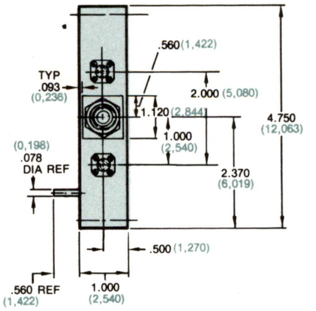
ELECTRICAL SPECIFICATIONS

Frequency Range	DC-16.5 GHz	
Typical Insertion Phase at Minimum Phase Setting	300 Degrees/GHz	
Phase-Shift (Degrees/GHz)	27.5	
Phase-Shift (Degrees/GHz/Shaft-Turn)	1.91	
Phase-Shift (Degrees at Maximum Frequency)	341 (DC-12.4)	454 (12.4-16.5)
VSWR	1.5 (Max. DC-12.4)	2.2 (Typ. 12.4-16.5)
Insertion Loss (dB)	0.7 x GHz + .1 (Max. DC-12.4)	1.3 (Typ. 12.4-16.5)
Average Power at Maximum Frequency	35 Watts*	
Peak Power at Sea Level, 25°C	1.0 KW	
Operating Temperature Range	−55°C to +100°C	

*Derate average power 50% if phase is adjusted with power applied.
Derate average power linearly with temperature above 50°C to 50% at 100°C.

MECHANICAL DATA


(4) .159 (0,404) DIA THRU
INDICATOR ARM
(2) FEMALE SMA CONNECTOR
4.375 ± .010 (0,025) (11,110)
.250 (0,635)
+.000 (0,000)
.250 −.005 (0,013) (0,635)
.062 (0,157)
1.63 (4,139)
.560 REF (1,422)
.450 MIN (1,143)
1.800 (4,571)
.190 (0,483)
3.000 ± .010 (7,619) (0,025)
.781 (1,983)
4.560 (11,580)
.380 (0,965)
1.000 (2,540)


.560 (1,422)
TYP .093 (0,236)
2.000 (5,080)
1.120 (2,844)
4.750 (12,063)
1.000 (2,540)
(0,198) .078 DIA REF
2.370 (6,019)
.500 (1,270)
.560 REF (1,422)
1.000 (2,540)

MATERIALS & FINISHES

Fabricated in aluminum & brass
Cases iridited & painted Sage
Hammertone Green
Connectors passivated stainless steel

All other metals silver-plated
& rhodium-flashed
All SAGELINE materials and finishes
to Govt. specs

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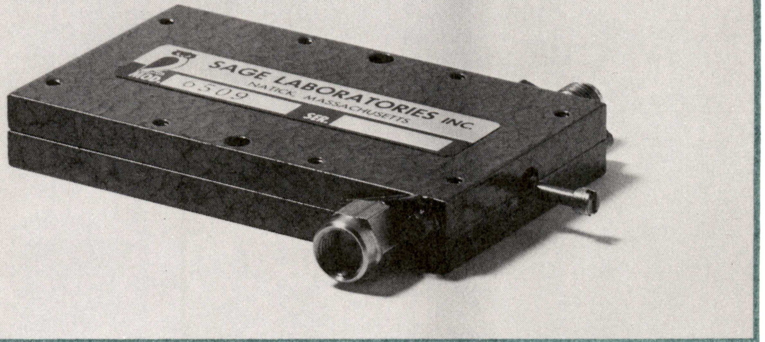
MODEL 6509 COAXIAL VARIABLE PHASE-SHIFTER (COVERS DC-18 GHz)

FEATURES

- DC-18 GHz
- SMA connectors
- compact unit
- rugged construction

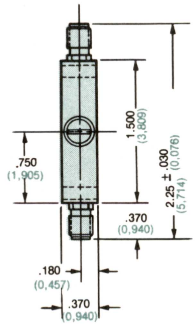

SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
6509
SER.

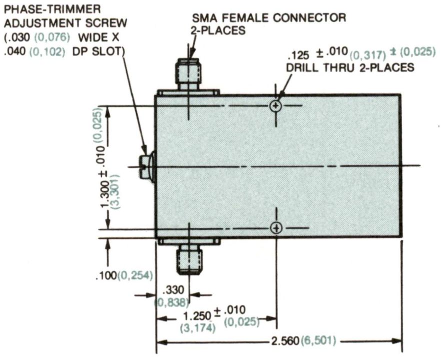
ELECTRICAL SPECIFICATIONS

Frequency Range	DC-18 GHz		
Typical Insertion Phase at Minimum Phase Setting	140 Degrees/GHz		
Phase-Shift (Degrees/GHz)	40		
Phase-Shift (Degrees/GHz/Shaft-Turn)	1.48		
Phase-Shift (Degrees at Maximum Frequency)	240 (DC-6)	480 (6-12)	720 (12-18)
Maximum VSWR	1.5 (DC-6)	1.75 (6-12)	2.0 (12-18)
Maximum Insertion Loss (dB)	0.5 (DC-6)	1.0 (6-12)	2.0 (12-18)
Average Power at Maximum Frequency	35 Watts*		
Peak Power at Sea Level, 25°C	1.0 KW		
Operating Temperature Range	−55°C to +100°C		

*Derate average power 50% if phase is adjusted with power applied.
Derate average power linearly with temperature above 50°C to 50% at 100°C.

MECHANICAL DATA


1.500 (3,809)
2.25 ± .030 (5,714) (0,076)
.750 (1,905)
.370 (0,940)
.180 (0,457)
.370 (0,940)


PHASE-TRIMMER ADJUSTMENT SCREW (.030 (0,076) WIDE X .040 (0,102) DP SLOT)
SMA FEMALE CONNECTOR 2-PLACES
.125 ±.010 (0,317) ± (0,025) DRILL THRU 2-PLACES
1.300 ± .010 (3,301) (0,025)
.100(0,254)
.330 (0,838)
1.250 ± .010 (3,174) (0,025)
2.560(6,501)

MATERIALS & FINISHES

Fabricated in aluminum & brass
Cases iridited & painted Sage Hammertone Green
Connectors passivated stainless steel

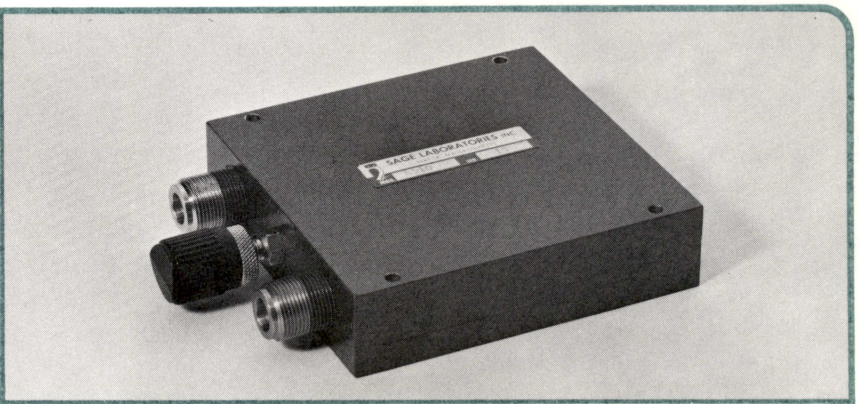
All other metals silver-plated & rhodium-flashed
All SAGELINE materials & finishes to Govt. specs

sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

MODEL 6510 COAXIAL VARIABLE PHASE-SHIFTER (COVERS DC-6 GHz)

FEATURES

- DC-6 GHz
- Type N female connectors
- rugged construction

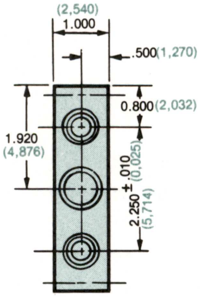


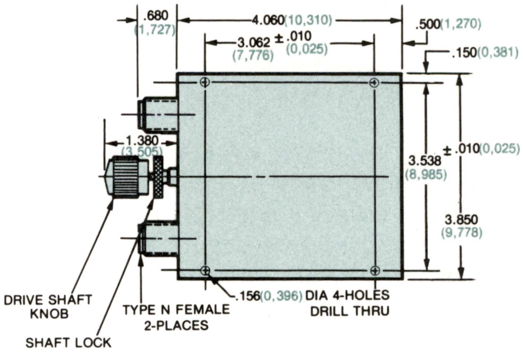
ELECTRICAL SPECIFICATIONS

Frequency Range	DC-6 GHz	
Typical Insertion Phase at Minimum Phase Setting	260 Degrees/GHz	
Phase-Shift (Degrees/GHz)	93	
Phase-Shift (Degrees/GHz/Shaft-Turn)	2.60	
Phase-Shift (Degrees at Maximum Frequency)	560	
VSWR	1.2 (Max. DC-2.3)	1.35 (Typ. 2.3-6)
Insertion Loss (dB)	0.2 (Max. DC-2.3)	0.3 (Typ. 2.3-6)
Average Power at Maximum Frequency	300 Watts*	
Peak Power at Sea Level, 25°C	2.5 KW	
Operating Temperature Range	−55°C to +100°C	

*Derate average power 50% if phase is adjusted with power applied.
Derate average power linearly with temperature above 50°C to 50% at 100°C.

MECHANICAL DATA


(2,540)
1.000
.500(1,270)
0.800(2,032)
1.920
(4,876)
2.250 ±.010
(5,714) (0,025)


.680
(1,727)
4.060(10,310)
.500(1,270)
3.062 ±.010
(7,776) (0,025)
.150(0,381)
1.380
(3,505)
3.538 ±.010(0,025)
(8,985)
3.850
(9,778)
.156(0,396) DIA 4-HOLES
DRILL THRU
DRIVE SHAFT
KNOB
TYPE N FEMALE
2-PLACES
SHAFT LOCK

MATERIALS & FINISHES

Fabricated in aluminum & brass
Cases iridited & painted Sage
Hammertone Green
Connectors passivated stainless steel

All other metals silver-plated
& rhodium-flashed
All SAGELINE materials & finishes
to Govt. specs

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APPLICATION NOTES COAXIAL VARIABLE PHASE-SHIFTERS & LINE-STRETCHERS

GENERAL NOTES ON USE

All standard Sage phase-shifter designs are based upon the mechanical lengthening or shortening of a 50-ohm transmission line. With this design approach, residual insertion phase and phase-shift are functions of frequency.* These parameters are tabulated on the standard product pages.

The type of phase-shifter manufactured by Sage is ideal for the correction of cable length irregularities in phase-dependent systems such as monopulse receivers and phased arrays.

SERVO DRIVE CONSIDERATIONS

In some applications, you may find it desirable to drive the phase-shifter lead screw with a servomechanism. In such cases, you should take into consideration the torque of the lead screw (typically 5 to 10 ounce-inches). Also, you will need some means of reversing the servo motor at the end of the phase-shifter's travel. Sage can provide units with dowel pins, which can be used to actuate limit switches which will reverse the servomechanisms.

MORE ACCURATE READOUT OF MECHANICAL DISPLACEMENT

The simplest approach is to use a multiturn digital dial. The Spectrol Model 15-2-11, illustrated in the OPTIONS for Models 6501-6506, provides readout accuracy to 0.01 revolution.

With some additional effort, we can install a micrometer drive or a dial indicator. In most applications, however, the increased complexity of these modifications is unwarranted, because system VSWR and component VSWR will produce phase uncertainties which exceed the uncertainties related to mechanical position of the phase-shifter lead screw.

POWER CONSIDERATIONS

The peak and average power ratings of Sage phase-shifters and line-stretchers are determined by the cross-sections of the transmission lines. The critical gaps are in air; therefore, peak power should be derated in accordance with standard scale factors for altitude, temperature and VSWR.

Average power should be derated from full power at 50°C to 50% at 100°C. Average power should also be derated by a factor of $1/\sqrt{\text{frequency}}$. If you adjust phase with power applied, derate the average power 50%.

*The FS1783 Goniometer (see Custom Engineering Capabilities, this product section) uses a different design approach, in which phase-shift is independent of frequency.

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COAXIAL & WAVEGUIDE FILTERS

CONTENTS OF THIS SECTION **PAGE**

A Guide to Selection **15**
Custom Engineering Capabilities **16-27**
Standard Products **28-36**

A GUIDE TO SELECTION

Previous editions of the Sage catalog have only hinted at the company's capabilities in microwave filters, because only standard catalog models were shown. Most of Sage Laboratories' filter work lies in the area of custom engineering. This edition of our catalog devotes major coverage to our custom engineering capabilities in microwave filters, and even at that, merely skims the surface of our filter developments.

For purposes of cost and delivery, you will want to study our standard filter data pages first. If you do not find what you need among our standard filters, we urge you to study carefully the section on custom-engineered designs. We may already have developed precisely what you need, or with minor modification of previously developed designs, we may be able to meet your needs with minimum engineering time.

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CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS

GENERAL

Sage Laboratories has designed and manufactured microwave filters and multiplexers ranging from highly sophisticated units for national defense and aerospace programs to low cost, high power filters for diathermy machines. Sage engineers have designed comb line filters which are free of spurious response out to four times the passband. Sage Laboratories has the capability to design in both TEM mode and waveguide mode transmission lines. Units can be custom designed, using digital and analog techniques, to meet stringent requirements with regard to group delay, flatness, and other parameters. The fabrication capabilities of Sage Laboratories include wire bonding, chemical etching, precision machining, torch brazing, and dip brazing.

By their very nature, microwave filters are inclined to be custom engineered to customer requirements. As a result, it is impossible to show more than a sampling of the filter designs developed at Sage since 1955. The custom designs shown on these pages represent an across-the-spectrum sampling of our developments in filters.

COAXIAL INTERDIGITAL BANDPASS FILTERS

For various customers over the years we have developed 16-section interdigital designs featuring sharp cut-off and low passband insertion loss. Here we have tabulated seven such designs, each of which features passband insertion loss of 1.5 dB maximum.

SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS

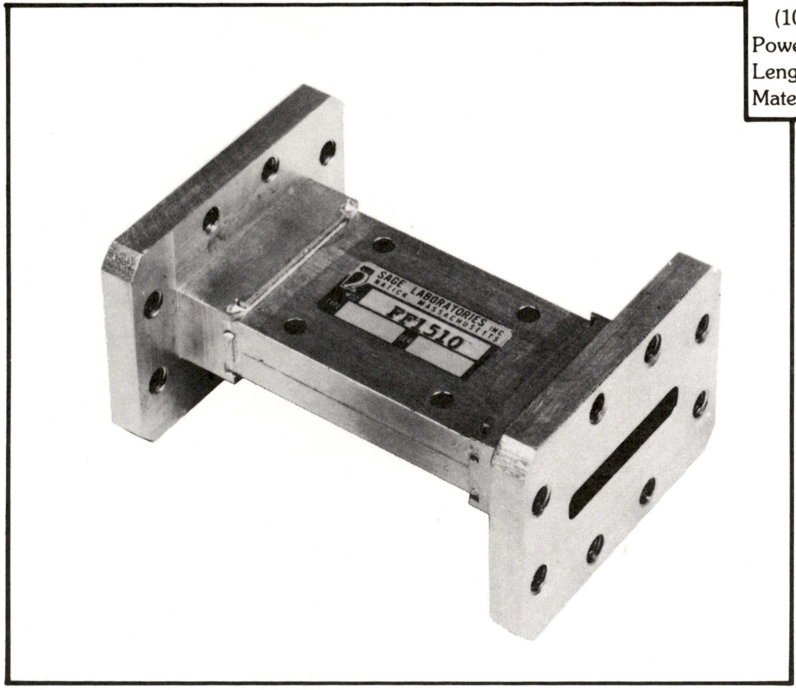
MODEL NUMBER	PASSBAND (GHz)	60 dB STOPBAND EDGES (GHz)*	
FF9482-1	1-2	0.8	2.2
FF9482-2	2-4	1.6	4.4
FF9482-3	4-6	3.5	6.5
FF9482-4	6-8	5.5	8.5
FF9482-5	8-10	7.5	10.5
FF9482-6	4-8	3.2	8.8
FF9482-7	8-12.4	6.9	13.5

*Higher-order passbands centered at odd multiples of fundamental center frequency.

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

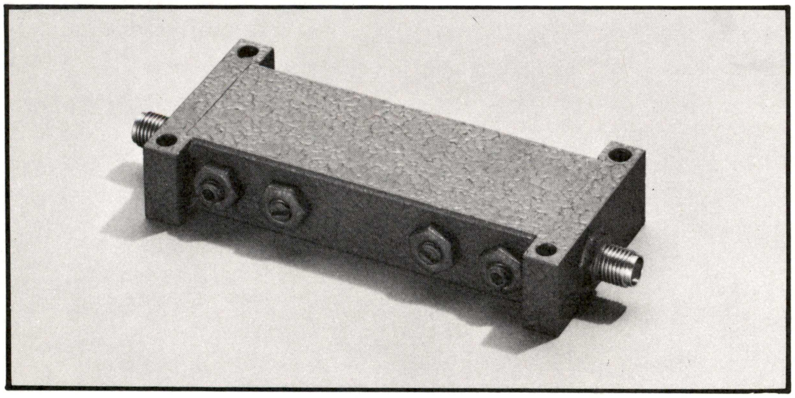
WAVEGUIDE LOW PASS FILTER (COMPACT, LOW LOSS, HIGH HARMONIC REJECTION)

Passband:	7.23-7.45 GHz (operable from 6.4-8.0 GHz)
Passband Insertion Loss:	< 0.1 dB
2nd & 3rd Harmonic Rejection:	> 60 dB
General Rejection (10-24.5 GHz):	40 dB minimum
Power Handling:	2 KW c-w
Length:	less than 3 inches
Mates with WR112 waveguide	



The FF1510 waveguide low pass filter was developed for a Japanese communications satellite. The unit is fully space qualified and is typical of many filters developed by Sage for space programs. Sage Laboratories holds a patent (#3949327) on this filter design.

FF 1039 BANDPASS FILTER (DEVELOPED FOR A MAJOR MICROWAVE INSTRUMENT MANUFACTURER)

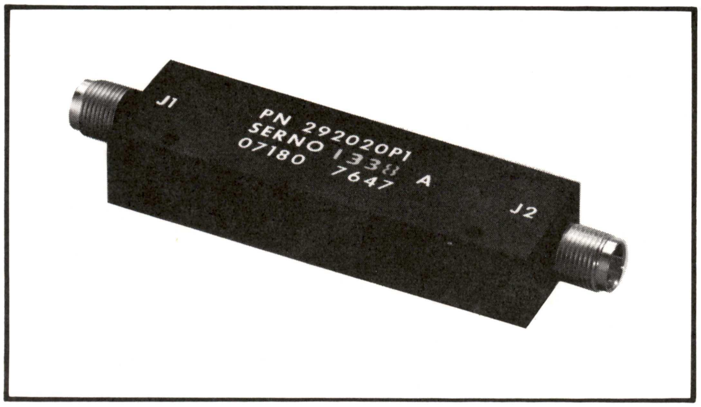


Over its 3940-4060 MHz passband, Model FF1039 has a maximum insertion loss of 3 dB and maximum peak-to-peak ripple of 1 dB. Stopband rejection is 70 dB minimum at 3700 MHz.

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

LOW PASS FILTER FOR HIGH ALTITUDE ELECTRONIC COUNTERMEASURES

Model F6943-2 is one of a series of low pass filters developed for a classified high altitude ECM system.

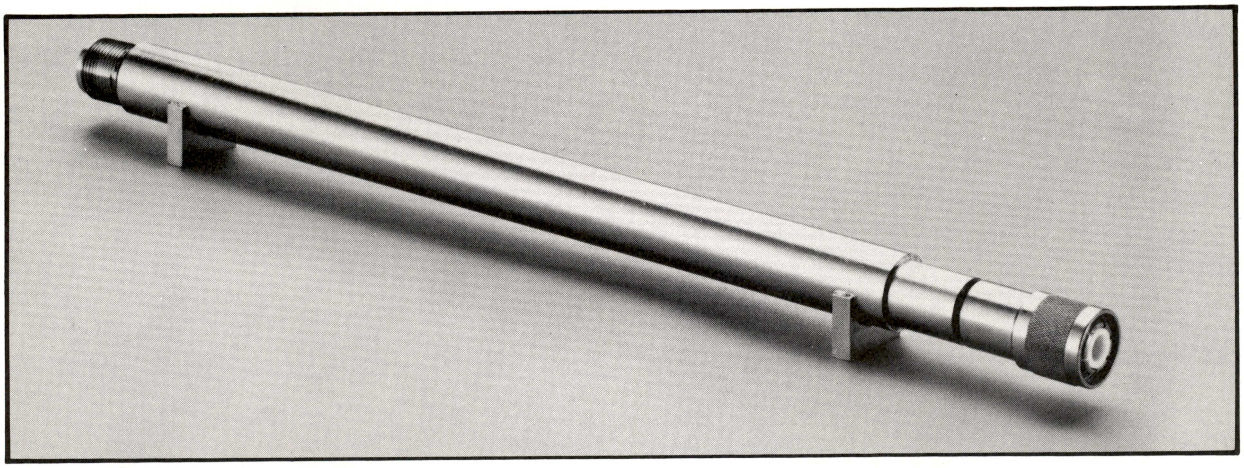


LOW PASS FILTER WITH BUILT-IN DIODE HOLDER

Designed for a receiver system mixer, Model L25CA023 was specified not to degrade the system's tangential signal sensitivity by more than 1.0 dB within the 1-2.5 GHz passband. Rejection is 30 dB minimum from 5-9 GHz.

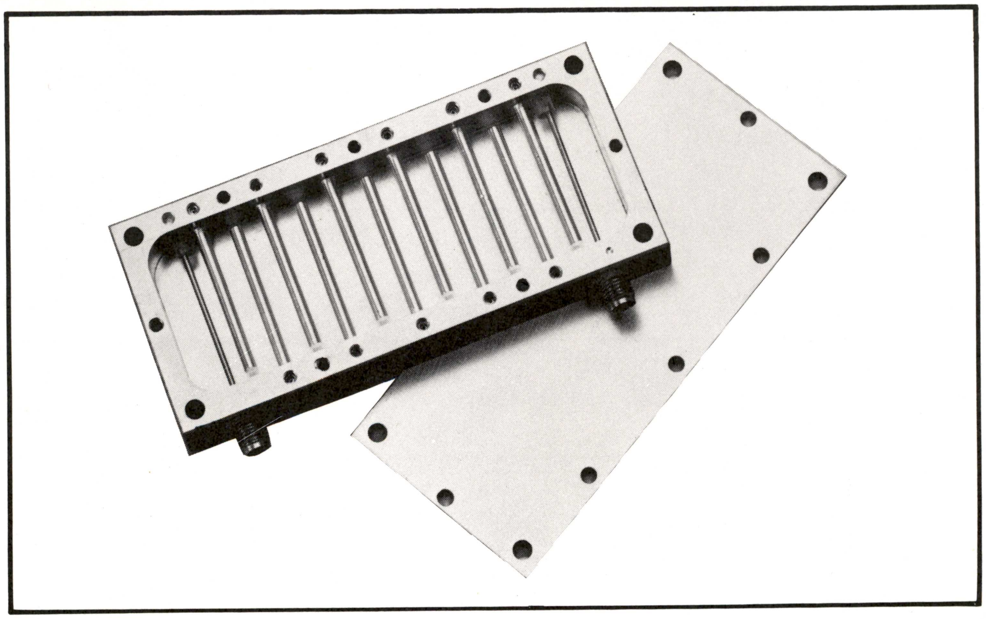
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

LOW PASS FILTER FOR TACAN TRANSMITTER (MEETS FAA REQUIREMENTS)



Designed to meet FAA requirements for operation in a TACAN transmitter system, Model FF1922 Low Pass Filter transmits 15 Kilowatts peak power (500 watts average) at 1030 MHz. Insertion loss is 0.5 dB maximum from 1026.5-1033.5 MHz, and 1 dB maximum from 1085-1095 MHz. Passband VSWR is less than 1.25:1. Rejection is 50 dB minimum from 1280-11,000 MHz. The unit measures 7/8" in diameter and 14½" in length. The connectors are type HN.

ECONOMICAL INTERDIGITAL BANDPASS FILTERS (MODERATE BANDWIDTH)

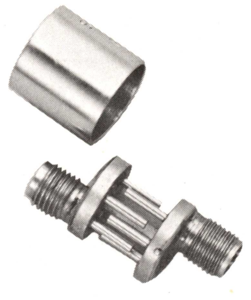


The filters in this series are moderate bandwidth (1% to 20%) units. Through the use of proprietary computer-assisted design techniques, Sage is able to make all the resonators in this type of filter the same round cross-section and diameter. Most other design approaches require different size resonators; this fact complicates design and assembly procedures. By standardizing resonator configuration, Sage is able to minimize non-recurring engineering (NRE) charges, and can produce filters of this type economically in small lots. This design approach can be applied to units ranging in operating frequency from UHF through K-band. The unit shown in the photograph is an L-band filter.

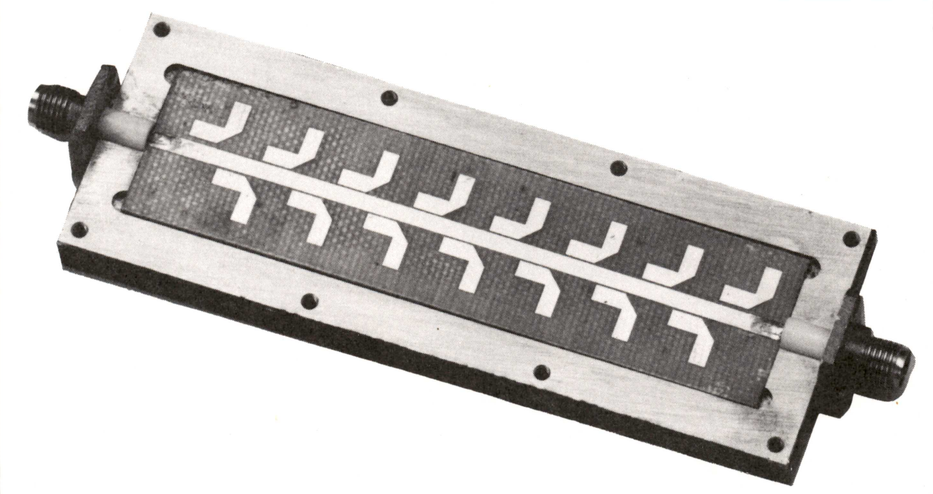
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (continued)

MINIATURE COAXIAL BANDPASS FILTERS

Patented interdigital design techniques enable Sage Laboratories to minimize the size of coaxial bandpass filters. These design techniques are ideal for broadband units. The unit shown in the photograph is a 4-8 GHz filter which typifies this patented approach. Units have been developed with passbands centered as high as K-band, and as low as 65 MHz. Even at 65 MHz, Sage engineers were able to hold the length of the units to 6 inches by using lumped capacitance loading of the interdigital fingers. For those particular units, the diameter was increased from 0.5" (as shown in the photo) to 1" to accomodate the loading circuits.

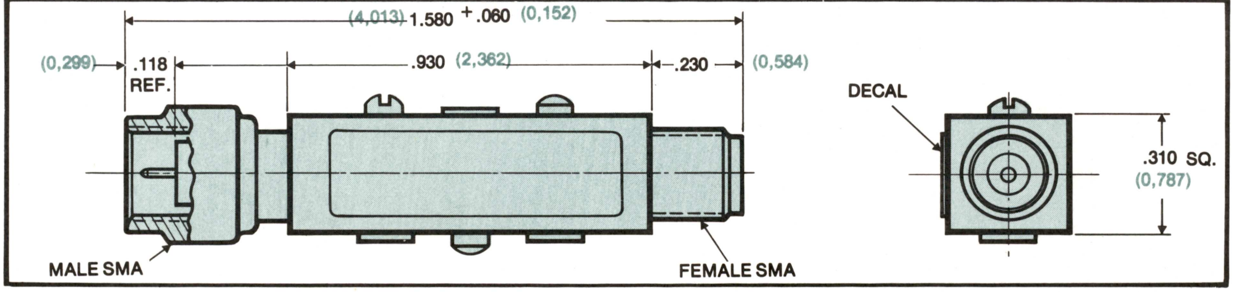

ACTUAL SIZE

BANDSTOP FILTERS USING STRIPLINE FABRICATION TECHNIQUES



The unit shown here (classified project) is an X-band multisection bandstop filter. It was fabricated in stripline on Teflon quartz to minimize the insertion loss. Sage has developed many such stripline filters for large production runs.

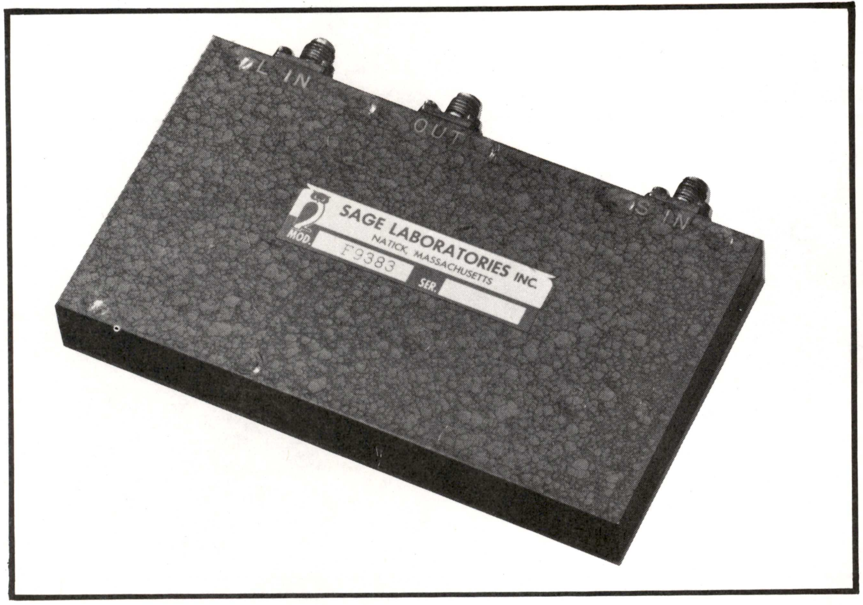
USE OF INTERDIGITAL TECHNIQUES TO DEVELOP HIGH FREQUENCY HIGH-PASS FILTERS



Model FF2160, illustrated above, is typical of development projects in which Sage engineers have taken advantage of the low frequency cut-off characteristics of interdigital structures to produce excellent high-pass filters at frequencies where other techniques would be impractical. Model FF2160 has a typical insertion loss of 1.0 dB over a 15.95-16.05 GHz passband. Rejection is 60 dB minimum below 12 GHz.

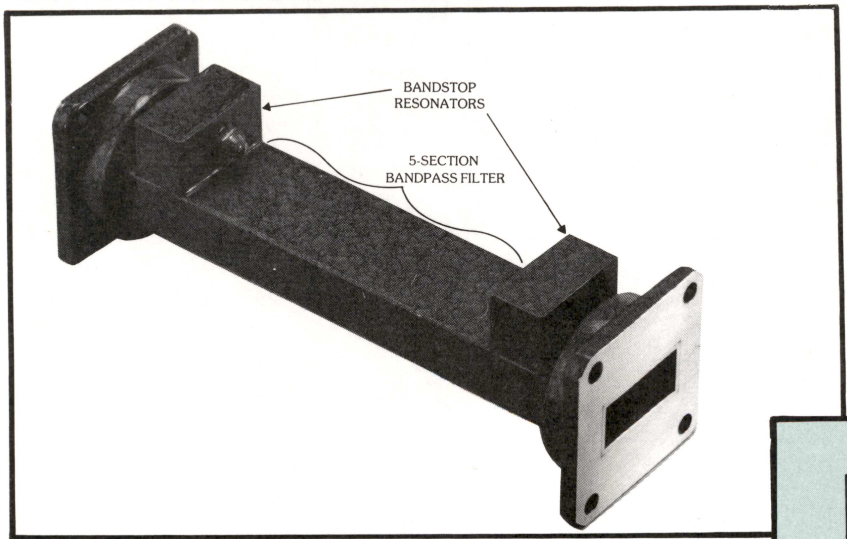
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

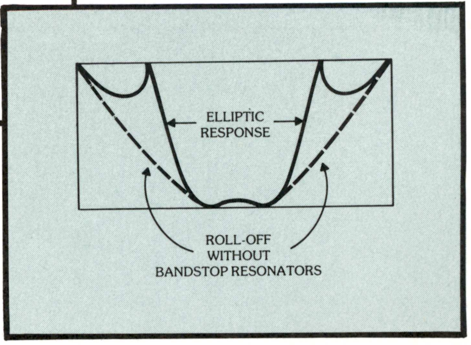
L BAND/S BAND DIPLEXERS FEATURE HIGH PERFORMANCE, LOW COST REPRODUCIBILITY



Chemically milled inter-digital structures provided low cost reproducibility in the F9383 series of miniature L-band/S-band diplexers. Insertion loss is 1.0 dB in both the 1435-1540 MHz and 2200-2300 MHz bands, and isolation between the L and S-band outputs is 30 dB minimum. In-band ripple is 0.2 dB maximum and phase linearity is ±3° from linear maximum in any 4 MHz portion of the passbands. The units met moisture sealing requirements of MIL-E-5400, Class II.

X BAND WAVEGUIDE BANDPASS FILTERS FEATURE QUASI ELLIPTIC RESPONSE FOR STEEP REJECTION

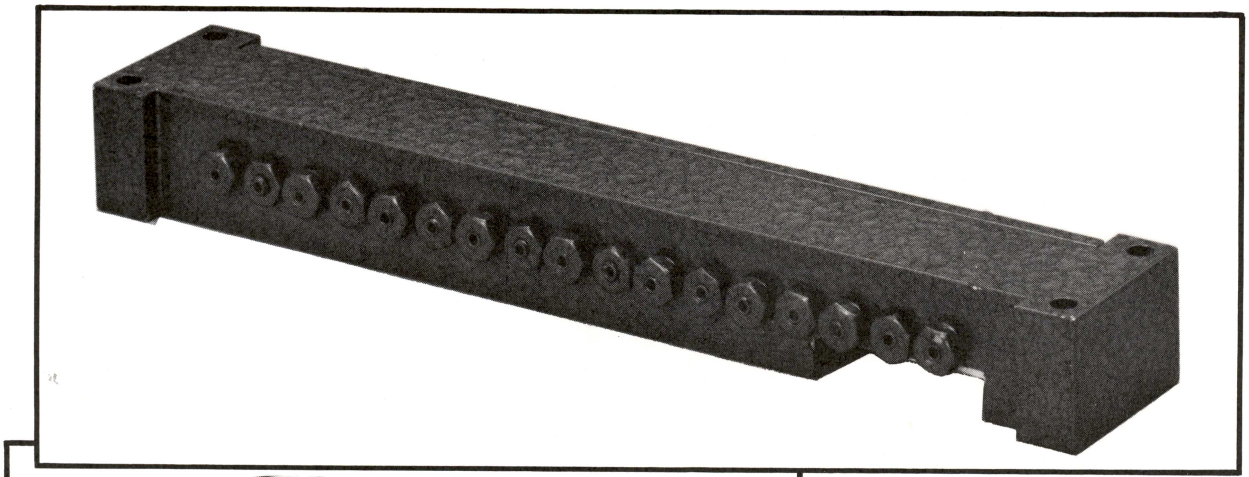


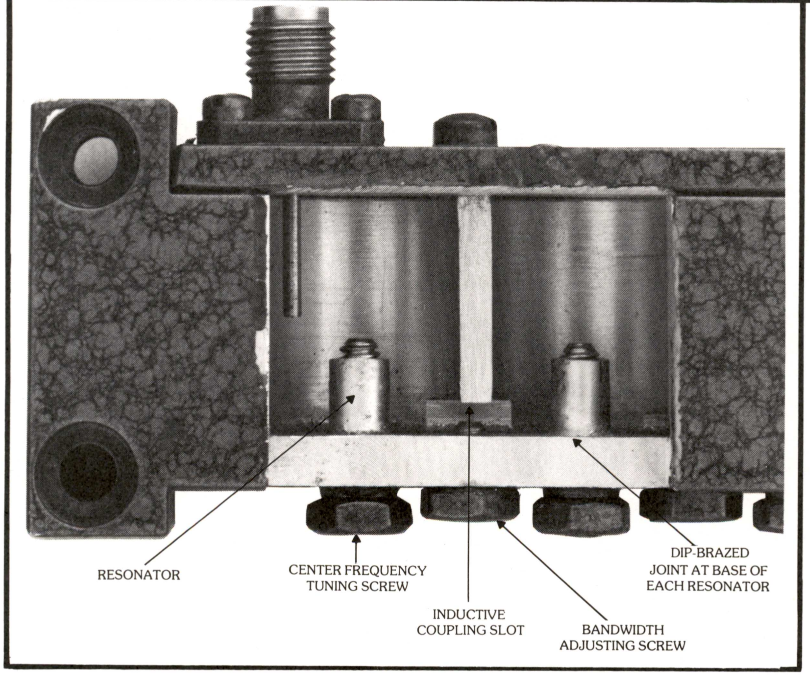


This unit (shown approximately ⅔ actual size) is typical of Sage-developed inductively coupled bandpass filters which use bandstop resonators to provide elliptic response. The accompanying curve shows how the resonator-induced quasi-elliptic response substantially steepens the rejection skirts at both ends of the passband.

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

C BAND INDUCTIVELY COUPLED CAVITY BANDPASS FILTERS FEATURE LOW LOSS, SMALL SIZE

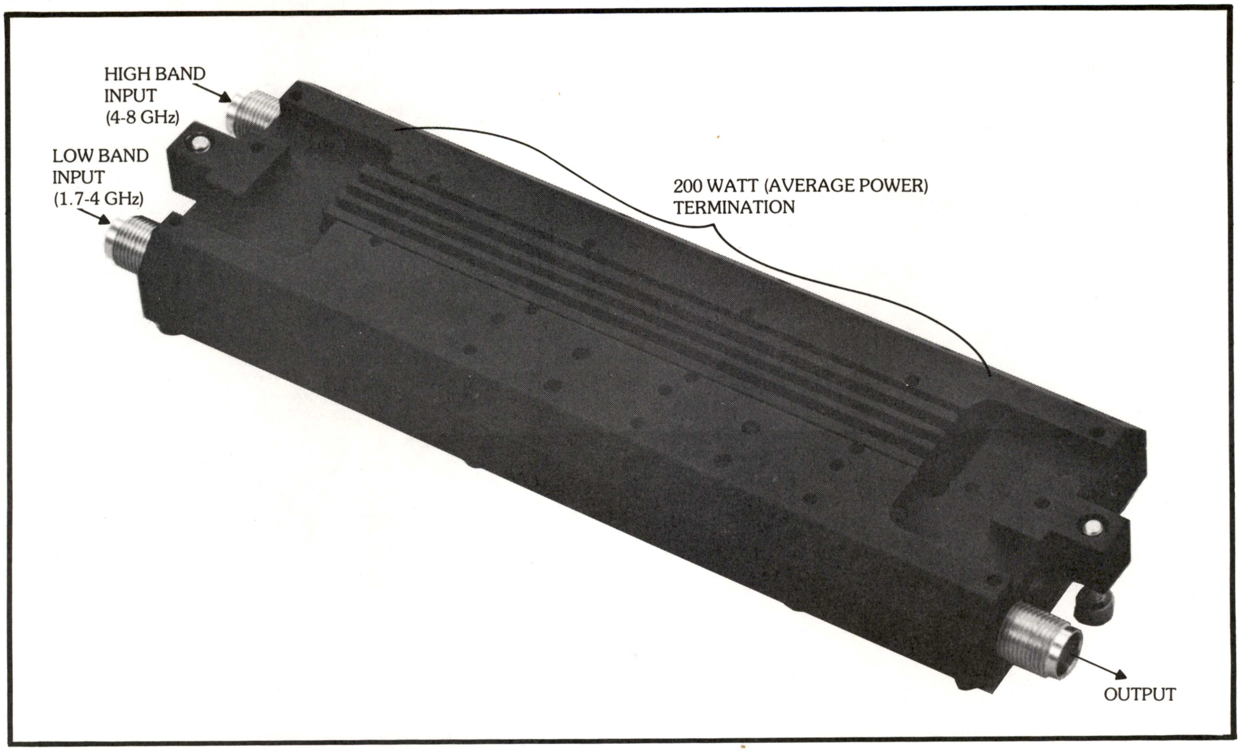



RESONATOR
CENTER FREQUENCY TUNING SCREW
INDUCTIVE COUPLING SLOT
BANDWIDTH ADJUSTING SCREW
DIP-BRAZED JOINT AT BASE OF EACH RESONATOR

An overall view of a C-band inductively coupled cavity bandpass filter is shown above. The cutaway view at left shows the internal construction of one cavity. This design permits the use of closely spaced, large cross-section cavities, which results in low loss, minimum size narrowband filters. Critical joints in the assembly were dip-brazed in our own dip-brazing facility.

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

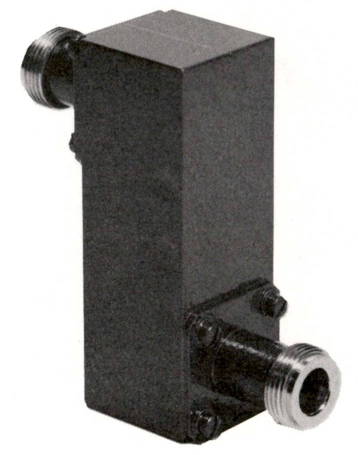
HIGH POWER DIPLEXERS FOR HIGH ALTITUDE ENVIRONMENT


HIGH BAND INPUT (4-8 GHz)
LOW BAND INPUT (1.7-4 GHz)
200 WATT (AVERAGE POWER) TERMINATION
OUTPUT

This high power diplexer was designed to operate from −55°C to +125°C ambient temperature at altitudes up to 70,000 feet. The built-in termination called out in the photograph provides a match for all frequencies at all ports, and maintains isolation between the low-band and high-band inputs.

PSEUDO HIGHPASS FILTER

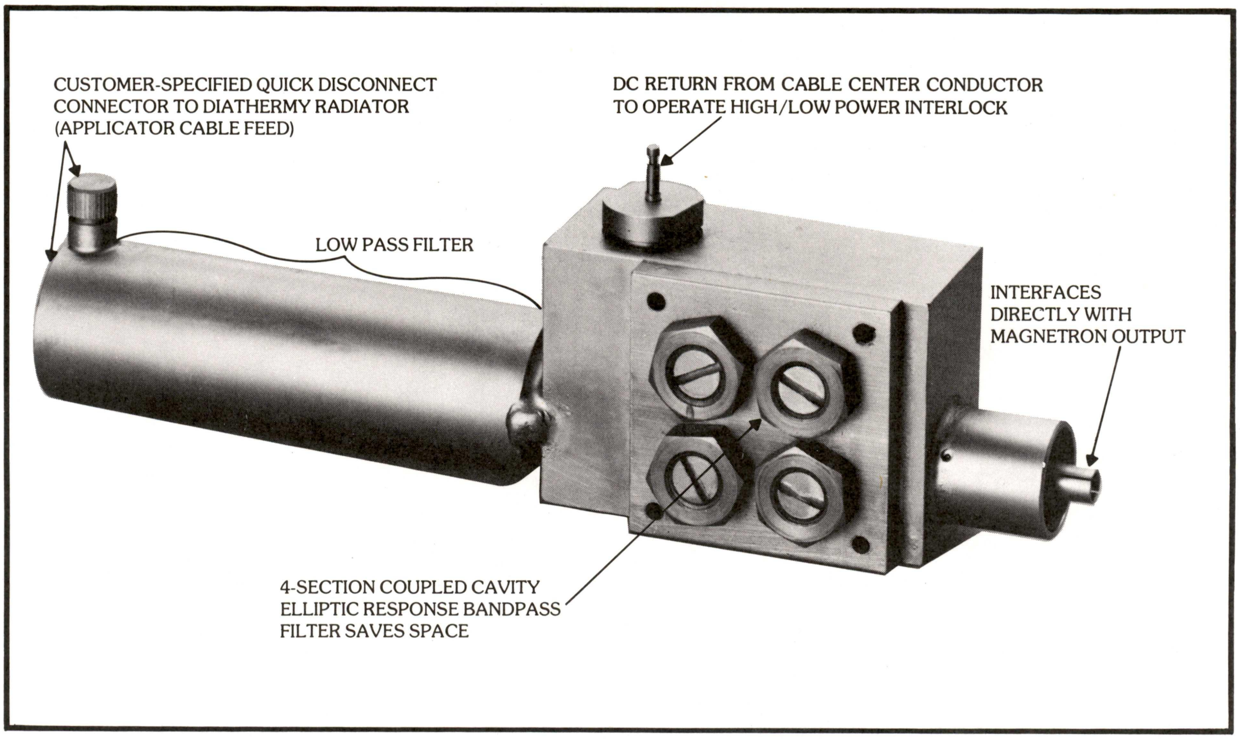
A customer's requirement called for a highpass filter with a 9-17 GHz passband. Inasmuch as highpass filters are difficult and expensive to fabricate at these frequencies, and because the customer's budget was limited, Sage engineers used an interdigital bandpass filter in a highpass mode. The result was a series of economical units having maximum insertion loss of 1 dB and maximum VSWR of 1.7:1 over the 9-17 GHz passband. Stopband rejection was 60 dB minimum at 5.5 GHz and 30 dB typical at 7.5 GHz. The model designation for this design is FF1470.



2/3 ACTUAL SIZE

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

RETROFIT DIATHERMY INTERFERENCE SUPPRESSION FILTER


CUSTOMER-SPECIFIED QUICK DISCONNECT CONNECTOR TO DIATHERMY RADIATOR (APPLICATOR CABLE FEED)
DC RETURN FROM CABLE CENTER CONDUCTOR TO OPERATE HIGH/LOW POWER INTERLOCK
LOW PASS FILTER
INTERFACES DIRECTLY WITH MAGNETRON OUTPUT
4-SECTION COUPLED CAVITY ELLIPTIC RESPONSE BANDPASS FILTER SAVES SPACE

Model F1711 was designed to fit into a restricted space formerly occupied by a simple low pass filter, so that a diathermy machine of European design could meet FCC interference specifications. The lower power of this machine's magnetron (compared to other diathermy machines for which Sage has designed filters) enabled our engineers to use an elliptic response bandpass filter, which saved considerable space compared to the comb filters used in higher power applications. (See Model F8982 diathermy filter)

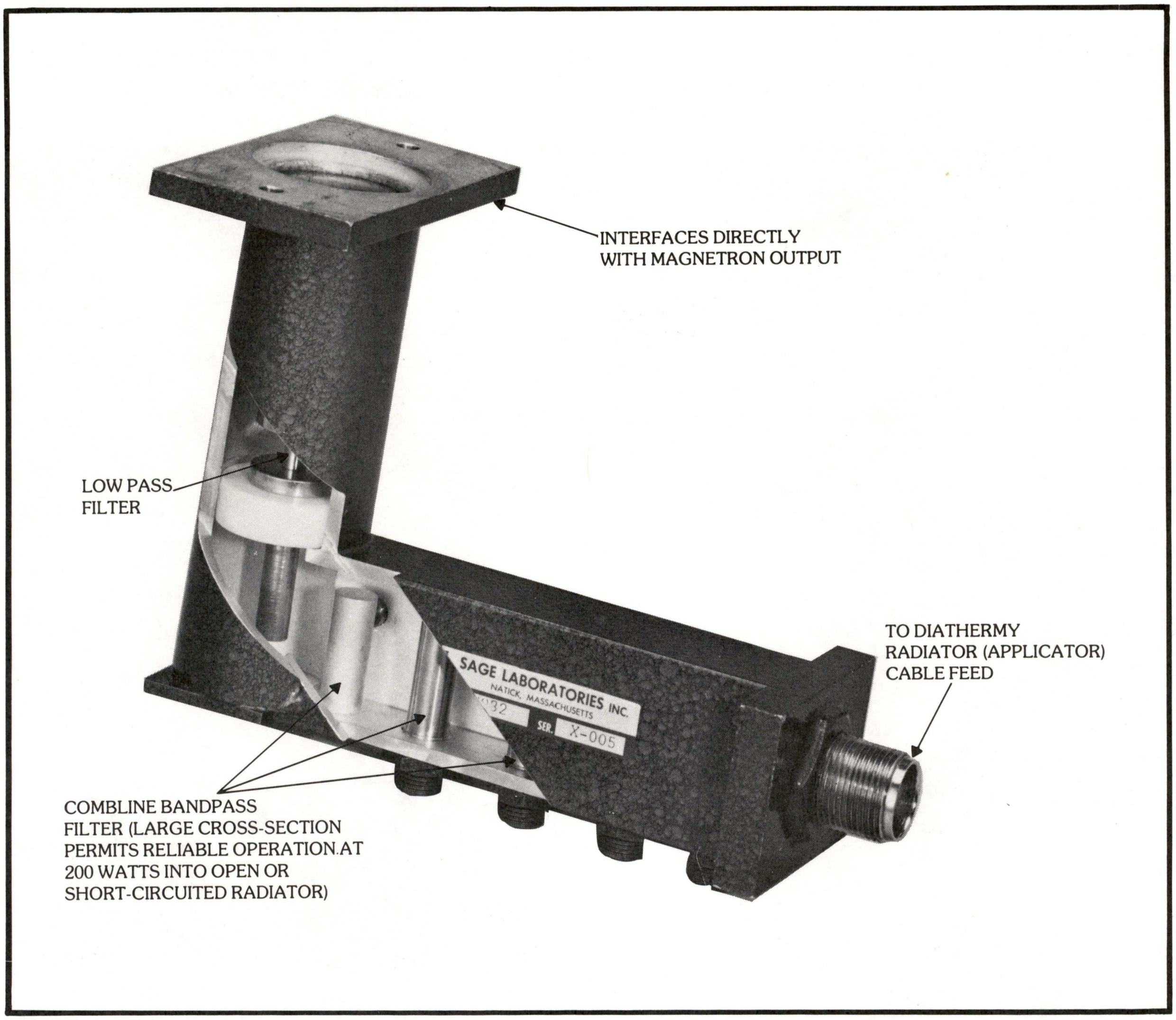
F1711 SPECIFICATIONS

PASSBAND.....Center Frequency: 2450 MHz
Insertion Loss: 1.5 dB maximum/1 dB typical
VSWR: 1.25:1 maximum
Power: 200 watts c-w
3-dB Bandwidth: 40 MHz minimum/50 MHz typical

STOPBAND REJECTION
at 2400 MHz and 2500 MHz.......... 20 dB minimum/30 dB typical
from 4800-5500 MHz................. 55 dB minimum
from 7250-7450 MHz................. 40 dB minimum/50 dB typical

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

OEM DIATHERMY INTERFERENCE SUPPRESSION FILTER


INTERFACES DIRECTLY
WITH MAGNETRON OUTPUT
LOW PASS
FILTER
SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
SER.
X-005
TO DIATHERMY
RADIATOR (APPLICATOR)
CABLE FEED
COMBLINE BANDPASS
FILTER (LARGE CROSS-SECTION
PERMITS RELIABLE OPERATION AT
200 WATTS INTO OPEN OR
SHORT-CIRCUITED RADIATOR)

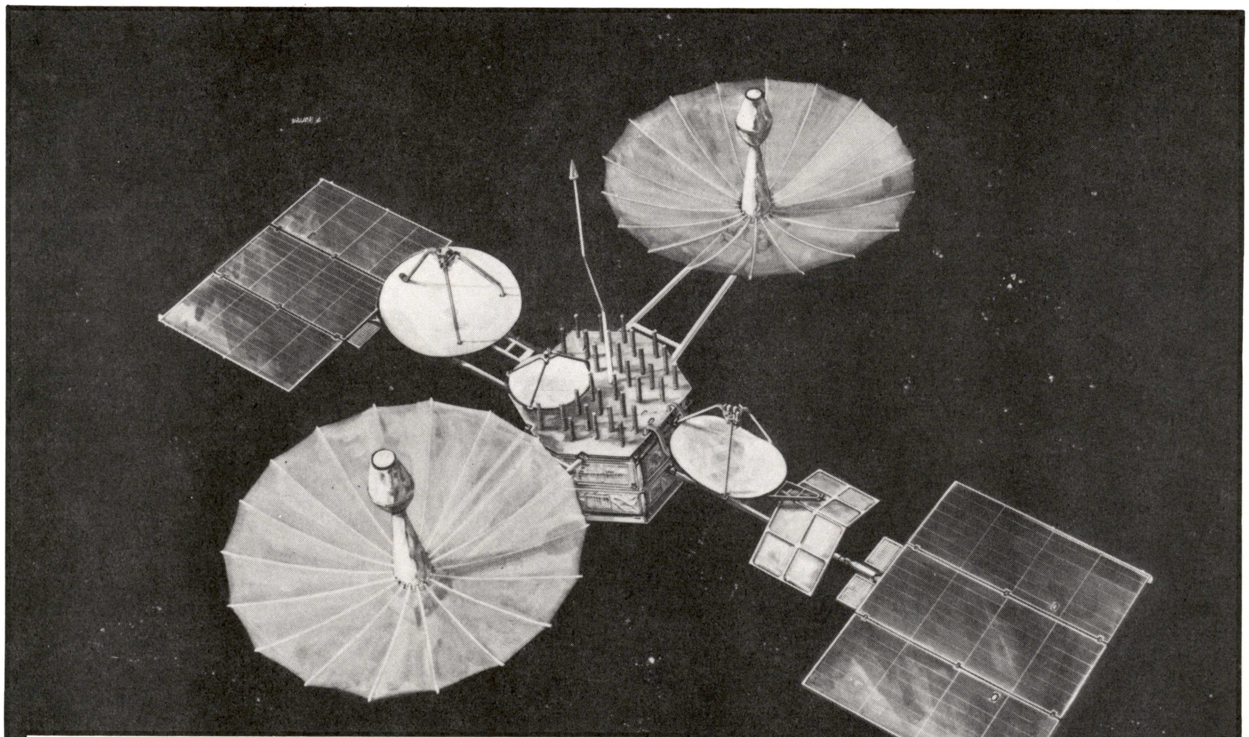
Model F8982 Diathermy Interference Suppression Filter was designed to be capable of operating into an RF load of any magnitude or phase without damage. Accordingly, a large cross-section combline bandpass filter was designed which could operate reliably at 200 watts c-w into an open-circuited or short-circuited radiator. The F8982 specifications are as follows.

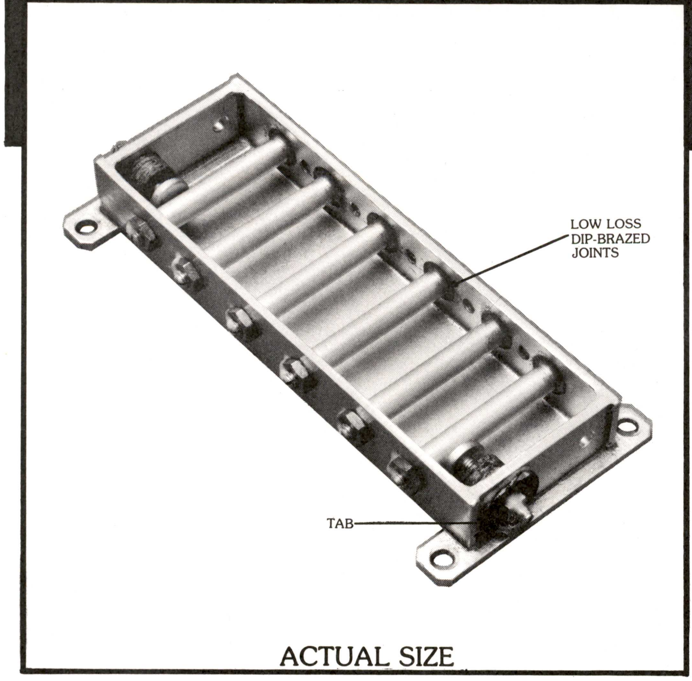
PASSBAND.............Frequency: 2425-2475 MHz (centered at 2450 MHz)
Insertion Loss: 1 dB maximum at 2450 MHz
VSWR: 1.5:1 maximum
Power: 200 watts c-w

STOPBAND REJECTION
at 2370 MHz and 2530 MHz........25 dB minimum
from 7275-7425 MHz................30 dB minimum
from DC-2300 MHz and 2600-5000 MHz.......... 55 dB minimum

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

COMBLINE BANDPASS FILTERS FOR TRACKING & DATA RELAY SATELLITE SYSTEM (TDRSS) FEATURE TAB INTERFACES FOR DIRECT INTERCONNECTION WITH SATELLITE MICROSTRIP CIRCUITRY



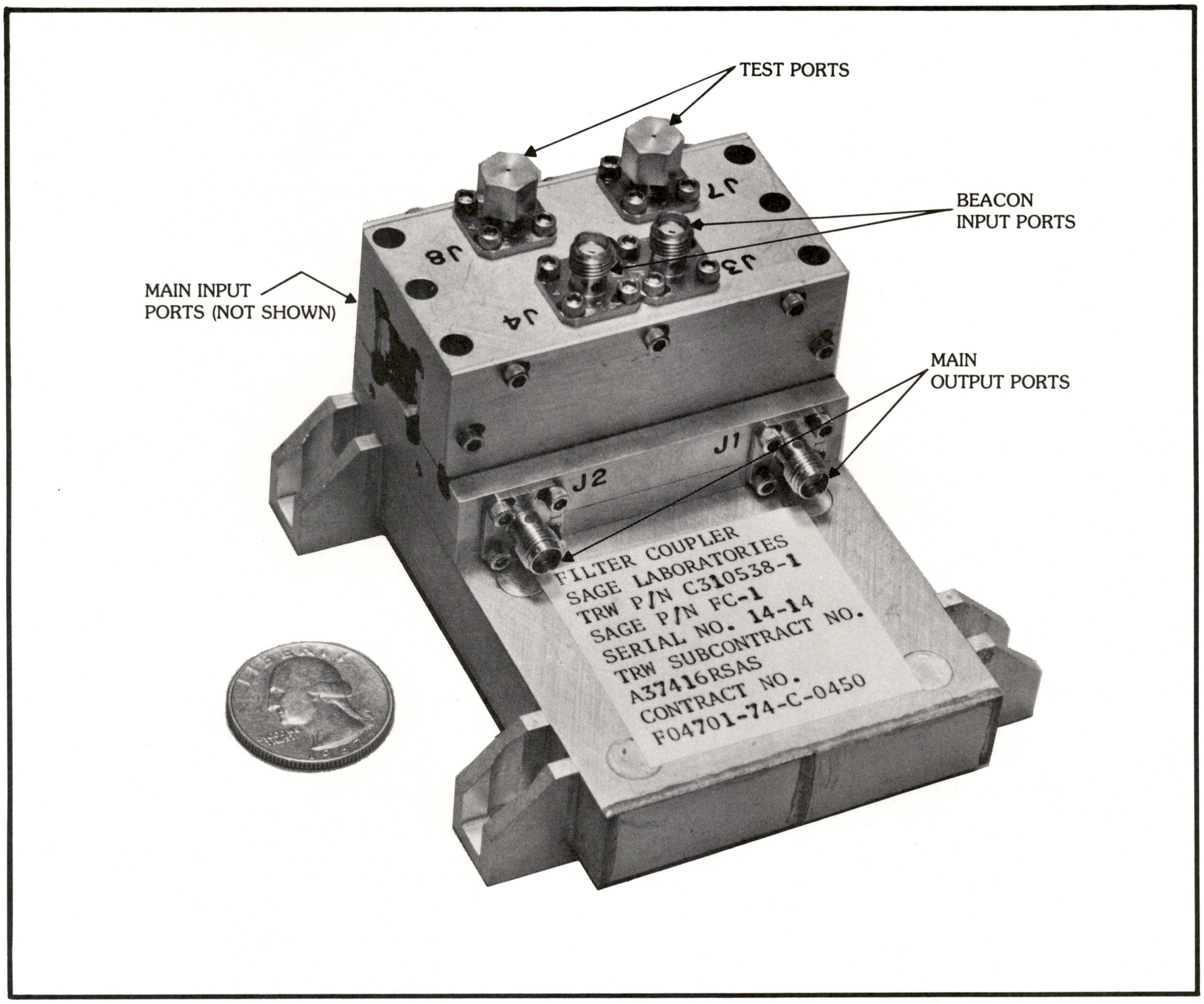


ACTUAL SIZE

Various combline bandpass filters like the unit shown were developed for the TDRSS satellite. Note the soldertab interfaces for direct connection with microstrip, and the low loss dip-brazed joints at the bases of the filter combs. Over the 2.0248-2.1189 GHz passband of the unit shown, VSWR is 1.2:1 maximum and insertion loss is 1.5 dB maximum. Amplitude ripple is 0.15 dB p-p maximum, and phase deviation is ±1° maximum, over any 14 MHz segment of the passband.

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL & WAVEGUIDE FILTERS (Continued)

FULLY REDUNDANT C-BAND FILTER-COMBINER FOR COMMUNICATIONS SATELLITE


TEST PORTS
BEACON INPUT PORTS
MAIN INPUT PORTS (NOT SHOWN)
MAIN OUTPUT PORTS
J7
J8
J3
J4
J1
J2
FILTER COUPLER
SAGE LABORATORIES
TRW P/N C310538-1
SAGE P/N FC-1
SERIAL NO. 14-14
TRW SUBCONTRACT NO.
A37416RSAS
CONTRACT NO.
F04701-74-C-0450

This compact package (shown here about 90% of actual size) contains a pair of 12-section dip-brazed interdigital filters, 4 microstrip circulators, 4 WIRELINE hybrids, 2 WIRELINE couplers, and 4 microstrip terminations. The microstrip circuits are thin film on ferrite substrates.

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DC BLOCKS
(NOISE SUPPRESSORS)

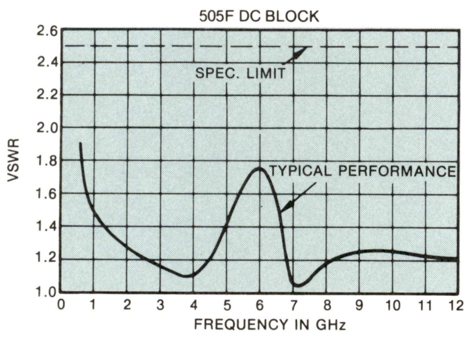
FEATURES

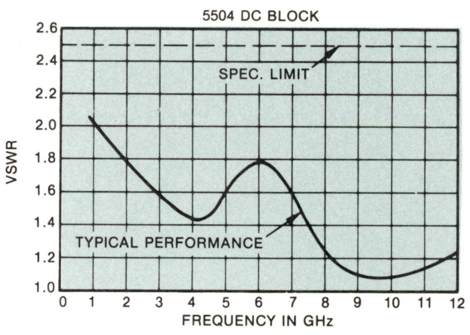
- isolate DC
- supress audio & RF to 10 MHz
- inner & outer conductors capacitively coupled
- low cost
- 1000 VDC minimum voltage breakdown (505F)

ELECTRICAL SPECIFICATIONS

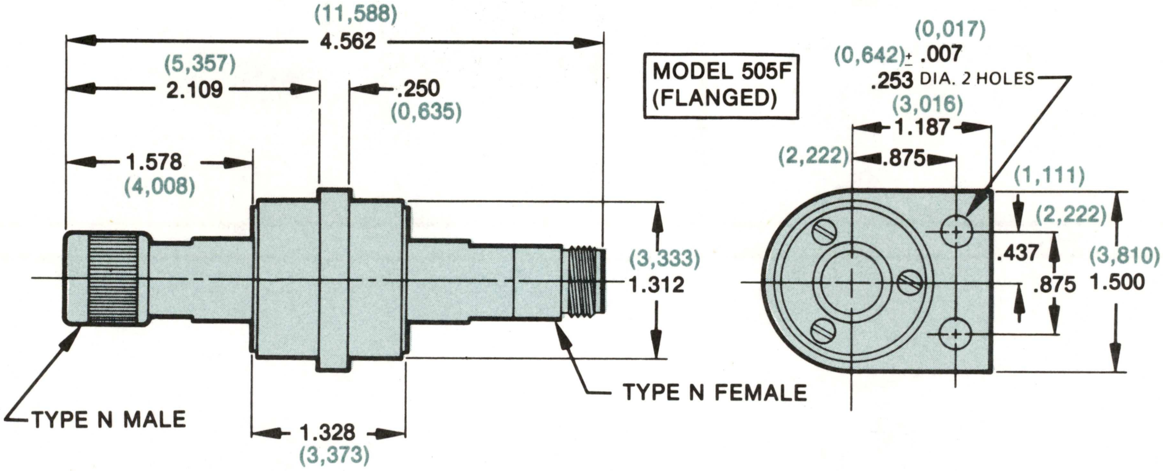
MODEL NUMBER	PASSBAND	MAXIMUM PASSBAND INSERTION LOSS	MAXIMUM PASSBAND VSWR	AVERAGE PASSBAND VSWR	BREAKDOWN VOLTAGE	CONNECTORS
505F	.05-12 GHz	1.0 dB*	2.5	1.5	1000 VDC	"N" (M-F)
5504	0.7-12 GHz	0.75 dB	2.5	1.5	500 VDC	SMA (M-F)
5504F	0.7-12 GHz	0.75 dB	2.5	1.5	500VDC	SMA (F-F)
5504M	0.7-12 GHz	0.75 dB	2.5	1.5	500 VDC	SMA (M-M)

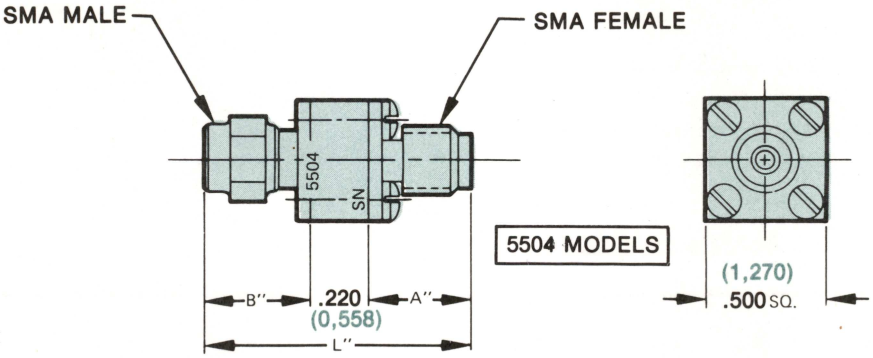
*50-500 MHz, 2.0 dB maximum





DC BLOCKS - MECHANICAL DATA


(11,588)
4.562
(5,357)
2.109
.250
(0,635)
1.578
(4,008)
(3,333)
1.312
TYPE N MALE
TYPE N FEMALE
1.328
(3,373)
MODEL 505F
(FLANGED)
(0,017)
(0,642)± .007
.253 DIA. 2 HOLES
(3,016)
1.187
(2,222)
.875
(1,111)
(2,222)
.437
.875
(3,810)
1.500


SMA MALE
SMA FEMALE
5504
SN
5504 MODELS
B"
.220
(0,558)
A"
L"
(1,270)
.500 SQ.

MODEL	CONNECTORS SMA	A ±.020 in.	A (0,050) cm	B ±.020 in.	B (0,050) cm	L ±.020 in.	L (0,050) cm
5504	MALE & FEMALE	0.37	(0,939)	0.43	(1,092)	1.02	(2,590)
5505F	FEM. & FEM.	0.37	(0,939)	0.37	(0,939)	0.96	(2,438)
5504M	MALE & MALE	0.43	(1,092)	0.43	(1,092)	1.08	(2,743)

MATERIALS & FINISHES

Fabricated in brass & Nylon
Beryllium copper coax contacts
All metals silver-plated & rhodium-flashed
5504 series painted Sage Hammertone Green

All SAGELINE materials & finishes to Govt. specs
Alternative materials & finishes available on special order

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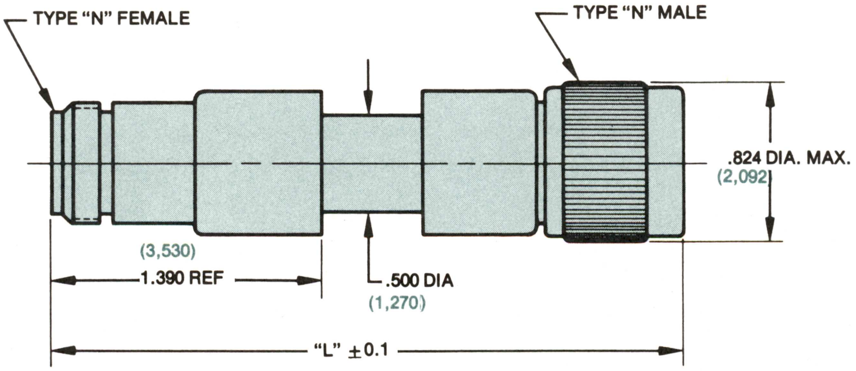
COAXIAL LOW PASS FILTERS

FEATURES

- 8 models covering 2-18 GHz
- bidirectional
- Tchebycheff ripple 0.01 dB in passband
- minimum 60 dB rejection in stopband
- rugged construction
- type N connectors (male & female)
- economically priced
- computerized design techniques offer quick turnaround & economical pricing on specials

MECHANICAL DATA



NOTE: Both male or female connector models available on special order

MODEL NO	CUT-OFF FREQ	L inches	L (cm)
L20CA072	2GHz	6.310	(16,027)
L30CA073	3GHz	4.750	(12,065)
L40CA074	4GHz	4.000	(10,160)
L60CA046	6GHz	3.400	(8,636)
L80CA047	8GHz	3.400	(8,636)
L10MA048	10GHz	2.850	(7,239)
L12MA049	12.4GHz	2.850	(7,239)
L18MA050	18GHz	2.850	(7,239)

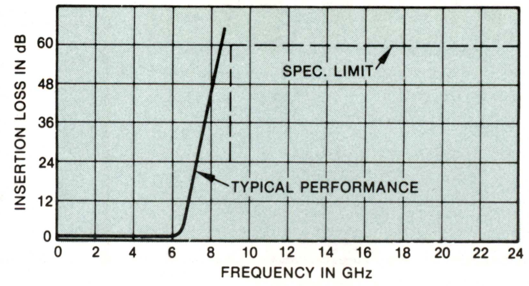
MATERIALS & FINISHES

Contacts are beryllium copper silver plated and gold flashed
Connector bodies are brass silver plated & rhodium flashed
All materials and finishes to Govt. specs
Alternative materials & finishes available on special order

COAXIAL LOW PASS FILTERS

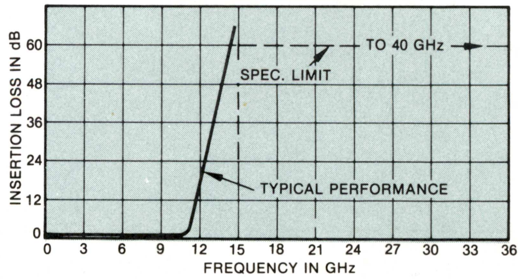
ELECTRICAL SPECIFICATIONS

LOW PASS FILTER L60CA046

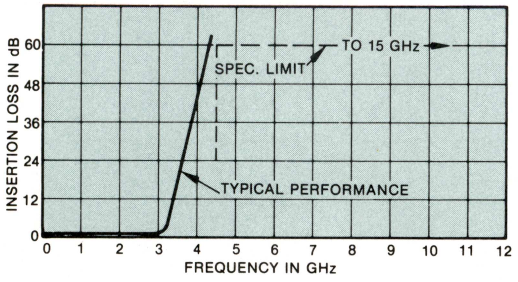


MODEL NUMBER	PASSBAND			STOP BAND 60 dB MIN REJECTION FROM 1.5 X Fc TO:
	DC TO GHz (Fc)	MAX VSWR	MAX INSERTION LOSS (dB)	
L20CA072	2.0	1.3	0.3	5 x Fc
L30CA073	3.0	1.3	0.3	5 x Fc
L40CA074	4.0	1.5	0.3	4 x Fc
L60CA046	6.0	1.5	0.4	4 x Fc
L80CA047	8.0	1.5	0.4	4 x Fc
L10MA048	10.0	1.5	0.5	4 x Fc
L12MA049	12.4	1.7	0.5	4 x Fc
L18MA050	18.0	1.75	0.75	4 x Fc

LOW PASS FILTER L10MA048



LOW PASS FILTER L30CA073



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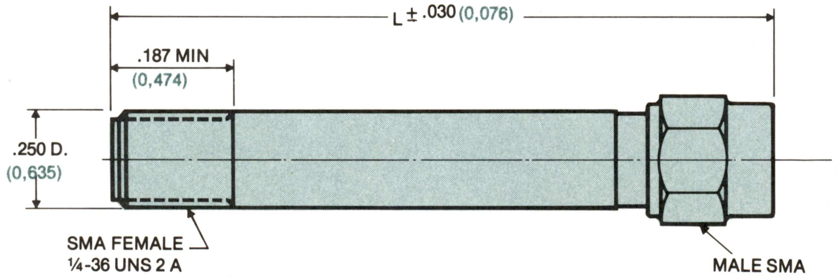
MINIATURE LOW PASS COAXIAL FILTERS

FEATURES

- 8 models covering 2-18 GHz
- bidirectional
- Tchebycheff ripple 0.01 dB in passband
- minimum 60 dB rejection in stopband
- rugged construction
- type SMA connectors
- economically priced
- computerized design techniques offer quick turnaround & economical pricing on special designs

MECHANICAL DATA



CONNECTOR OPTIONS

(Contact Factory for Prices)

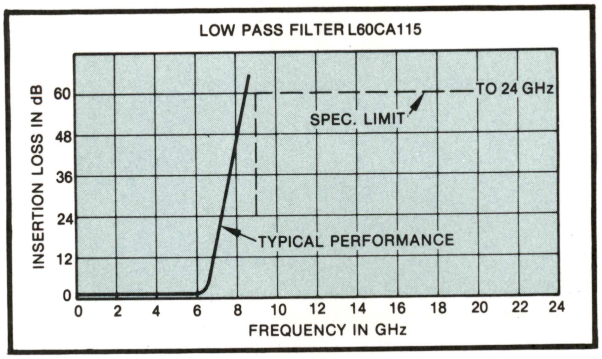
	Add Suffix
SMA Male-Male	M-M
SMA Female-Female	F-F

MATERIALS & FINISHES

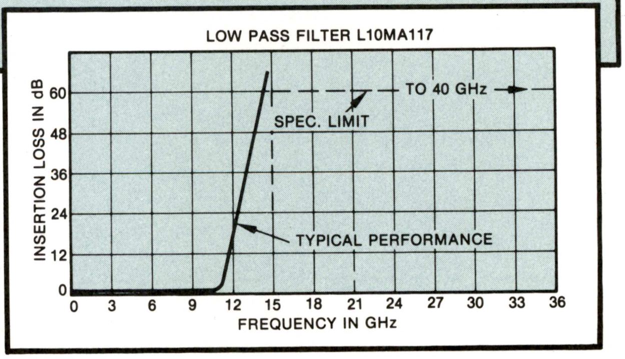
Bodies & contacts are beryllium copper, silver-plated & gold-flashed
All SAGELINE materials & finishes to Govt. specs
Alternative materials & finishes available on special order

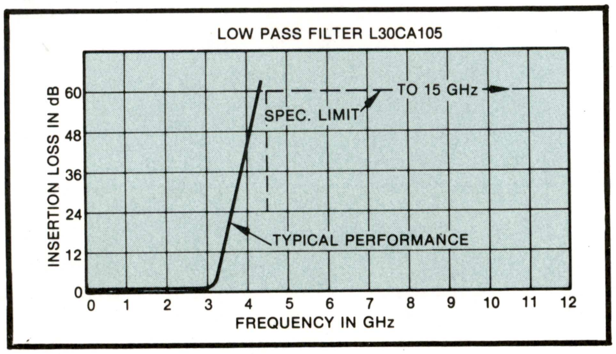
MODEL NUMBER	CUT-OFF FREQUENCY (GHz)	L” inches	L” cm
L20CA104	2.0	5.450	(13,843)
L30CA105	3.0	4.020	(10,210)
L40CA114	4.0	3.480	(8,839)
L60CA115	6.0	2.673	(6,789)
L80CA116	8.0	2.259	(5,737)
L10MA117	10.0	1.854	(4,709)
L12MA112	12.4	1.715	(4,356)
L18MA111	18.0	1.435	(3,644)

MINIATURE COAXIAL LOW PASS FILTERS ELECTRICAL SPECIFICATIONS



MODEL NO.	PASSBAND			STOP BAND 60 dB MIN. REJECTION FROM 1.5 x Fc TO:
	DC TO GHz (Fc)	MAX. VSWR	MAX. INSERTION LOSS (dB)	
L20CA104	2.0	1.3	0.3	5 x Fc
L30CA105	3.0	1.3	0.3	5 x Fc
L40CA114	4.0	1.5	0.3	4 x Fc
L60CA115	6.0	1.5	0.4	4 x Fc
L80CA116	8.0	1.5	0.4	4 x Fc
L10MA117	10.0	1.5	0.5	4 x Fc
L12MA112	12.4	1.7	0.5	4 x Fc
L18MA111	18.0	1.75	0.75	4 x Fc





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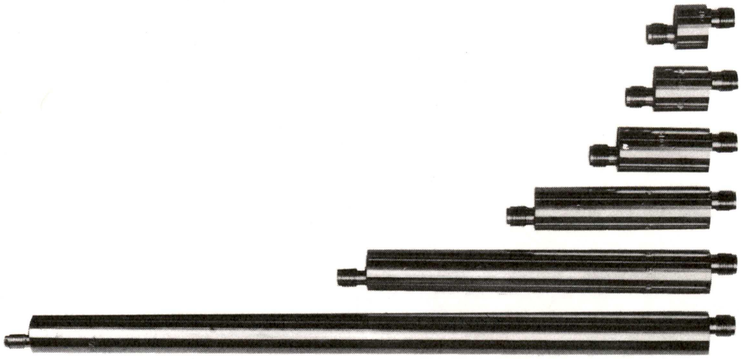
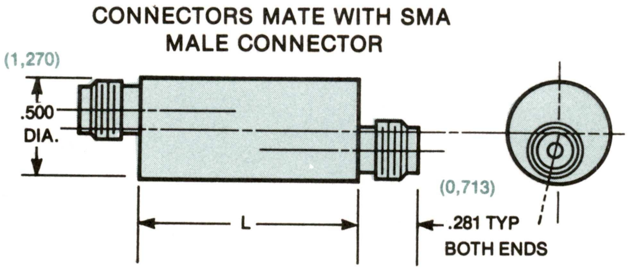
MINIATURE COAXIAL INTERDIGITAL BANDPASS FILTERS

FEATURES

- 6 standard models covering 250-12,400 MHz
- miniature size (1/2" diameter)
- light weight
- rugged construction
- SMA female connectors
- 8-section interdigital design



MECHANICAL DATA



MATERIALS & FINISHES

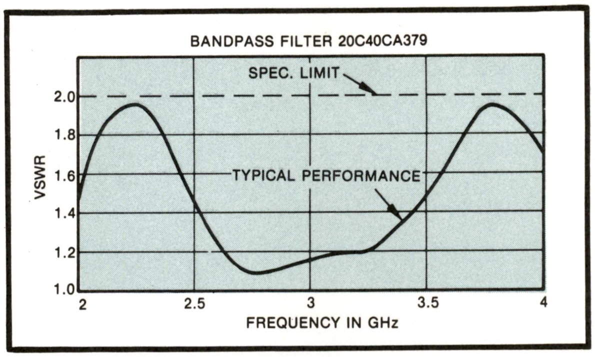
Fabricated in brass
Beryllium copper coax contacts
All metals silver-plated, rhodium-flashed

Alternative materials & finishes may be specified on special order
All SAGELINE materials & finishes to Govt. specs

MODEL NUMBER	FUNDAMENTAL PASSBAND (MHz) f low f high	LENGTH (L) inches	(cm)	WEIGHT (OUNCES)
25X50XA376	250-500	7.550	(19,177)	2.7
50X10CA377	500-1000	3.880	(9,855)	1.5
10C20CA378	1000-2000	2.020	(5,130)	1.0
20C40CA379	2000-4000	1.090	(2,768)	0.8
40C80CA427	4000-8000	.670	(1,701)	0.5
80C12MA425	8000-12,400	.500	(1,270)	0.4

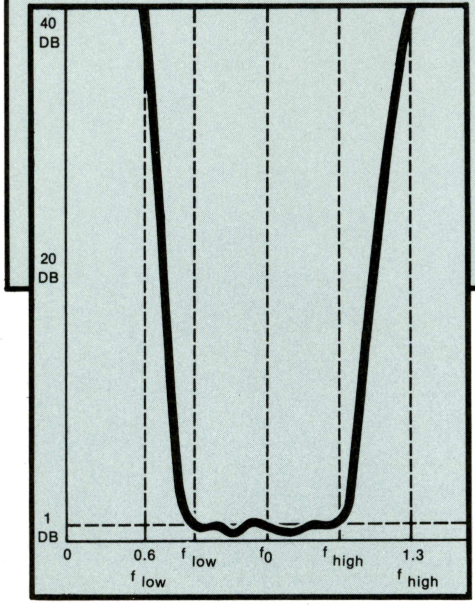
MINIATURE COAXIAL INTERDIGITAL BANDPASS FILTERS

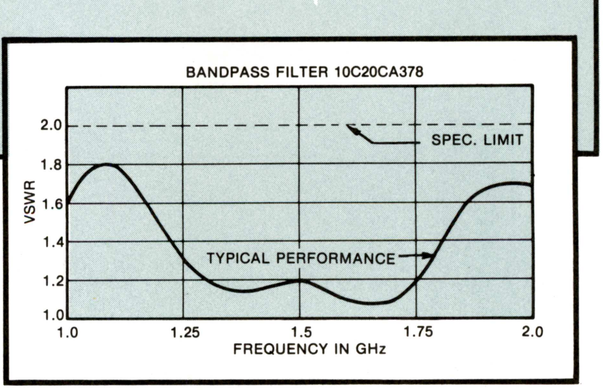
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	PASS BAND				STOP BAND*
	Fl (MHz)	Fh (MHz)	MAX VSWR	NOM. INSERTION LOSS (dB)	
25x50xA376	250	500	2:1	1 dB	40 dB nom.
50x10CA377	500	1000	2:1	1 dB	below
10C20CA378	1000	2000	2:1	1 dB	0.6 x Fl
20C40CA379	2000	4000	2:1	1 dB	and
40C80CA427	4000	8000	2.5:1	1.5 dB	above
80C12MA425	8000	12,400	2.5:1	1.5 dB	1.3 x Fh

*Higher-order passbands centered at odd multiples of fundamental center frequency





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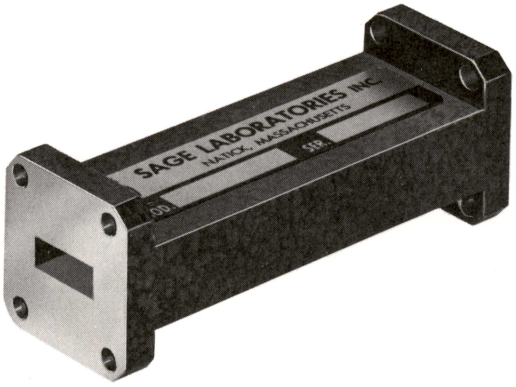
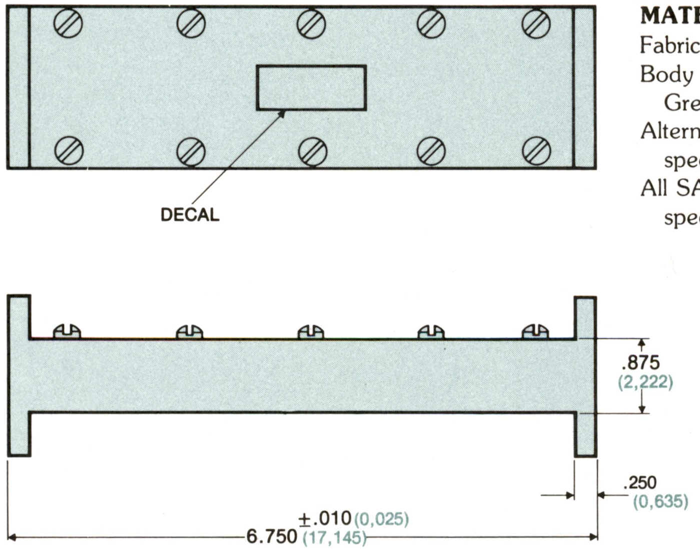
WAVEGUIDE LOW PASS BROADBAND FILTERS

FEATURES

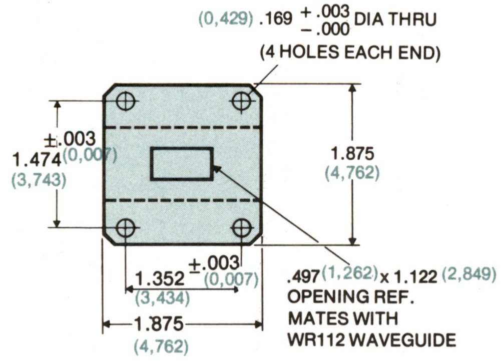
- 5 series covering 7.05-26.5 GHz
- rugged "waffle iron" construction
- low passband insertion loss
- full suppression of 2nd and 3rd harmonics


SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
SER.
MOD.


DECAL
.875
(2,222)
.250
(0,635)
±.010 (0,025)
6.750 (17,145)

MATERIALS & FINISHES

Fabricated in aluminum or brass, as required
Body surfaces painted SAGE Hammertone Green
Alternative materials & finishes supplied on special order
All SAGELINE materials & finishes to Govt. specs


(0,429) .169 +.003 −.000 DIA THRU
(4 HOLES EACH END)
±.003
1.474 (0,007)
(3,743)
1.875
(4,762)
1.352 ±.003 (0,007)
(3,434)
1.875
(4,762)
.497 (1,262) x 1.122 (2,849)
OPENING REF.
MATES WITH
WR112 WAVEGUIDE

Note: W10MA - ALUM. CONSTRUCTION
W10MB - BRASS CONSTRUCTION

ELECTRICAL & MECHANICAL DATA

SERIES	WAVEGUIDE (RETMA)	PASSBAND (FULL W.G.)	STOPBAND	MAX PASSBAND INSERTION LOSS	MINIMUM STOPBAND REJECTION	MAXIMUM PASSBAND VSWR	LENGTH inches	LENGTH (cm)
W10M	WR112	7.05-10GHz	13-27GHz	1 DB	45 DB	1.5	6.750	(17,145)
W12M	WR90	8.2-12.4GHz	16-38GHz	1 DB	45 DB	1.5	5.500	(13,970)
W15M	WR75	10-15.5GHz	20-48GHz	1 DB	45 DB	1.5	4.500	(11,430)
W18M	WR62	12.4-18GHz	24-55GHz	1 DB	45 DB	1.5	3.750	(9,525)
W26M	WR42	18-26.5GHz	34-80GHz	1 DB	45 DB	1.5	2.500	(6,350)

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COAXIAL ELECTROMECHANICAL SWITCHES

CONTENTS OF THIS SECTION **PAGE**

A Guide to Switch Selection **37–39**
Custom Engineering Capabilities **40-43**
Standard Products **44-59**
Application Notes **60-63**
Wiring & Installation Instructions **64**

A GUIDE TO SWITCH SELECTION

A coaxial switch is used to open, close, or divert the signal path in a coaxial transmission line. Coaxial switches are used in microwave systems to switch antennas from one receiver or transmitter to another, and to switch in tune-up instrumentation such as dummy loads, signal generators, and analyzers.

Coaxial electromechanical switches provide good shielding at low frequencies, efficient transmission of energy at all frequencies, and extremely broad operating bandwidths. The coaxial switch capabilities of Sage Laboratories extend from DC through 20 GHz.

Coaxial electromechanical switches perform the same basic functions as conventional low frequency relays, and are used in much the same ways, but they must be able to operate from DC through microwave frequencies. The key to this performance lies in switch construction. The internal geometry of a coaxial electromechanical switch is designed and fabricated to extremely tight electrical and mechanical tolerances.

Sage Laboratories manufactures coaxial electromechanical switches of two basically different types ... rotating coaxial line-section (*rotor*) type ... and *moving blade* type.

The *rotor type* switch uses a rotating drum or rotor containing a short section of coaxial line with a spring-loaded center contact to transfer the RF signal. The rotor can be controlled manually, or can be actuated remotely by means of a rotary solenoid. The center conductor is supported by teflon throughout its length. This construction provides a good thermal path and higher power capability than would be possible with an air line. The rotor type switch is the larger and heavier of the two switch types manufactured by Sage Laboratories.

In the *moving blade* switch, the contacting elements are short sections of coaxial center conductors which have been formed into flat blades. The blades can be controlled manually (see Toggle Switches), or can be actuated remotely by linear solenoids via insulated arms or levers. The comparatively small mass of the blades permits higher switching speeds with moving blade switches than with rotor switches.

Generally speaking, then, you can expect higher power capability with the rotor type switches, and higher switching speeds with the moving blade type switches. In all other respects, the two switch types are comparable.

Sage Laboratories has endeavored to provide a selection of standard switches offering you maximum versatility in mechanical and electrical parameters. We have designed basic switches which have very good RF and mechanical characteristics, and which are sufficiently modular in construction to achieve a high degree of versatility.

Typical of this modular design approach is our SA series of manual and remotely controlled multiposition switches. Using one basic rotor design, we offer 48 manual models and 48 remotely controlled models. The variations in models feature a choice of six RF connector types, two to six positions, and three different drive voltages.

Because of this modular approach, parts for most of our switches can be stocked, either in component form or in partially assembled form. This enables us to respond quickly to your needs.

The following Selection Guide matrix will help you select one of our standard switches that will meet your needs. If you require a special configuration, our engineers will design a unit to meet your specific needs. This can often be done by modifying a standard catalog design at nominal extra cost. The section following this one shows some specific illustrations of our capabilities in custom engineered switches. Your engineering inquiries are cordially invited.

SELECTION GUIDE TO SAGE LABORATORIES SWITCHES

PERFORMANCE CHARACTERISTICS	**SWITCH SERIES & APPLIANCE (X) CHARACTERISTICS**					
	SA	SB	SF	SHM	SK	ST
Single-Pole Double-Throw (SPDT)	X				X	X
Single-Pole Multiple-Throw (SPMT)	X			X		
Transfer		X	X			
Multiple-Pole Double-Throw (MPDT)						X
Indicator Light Circuits (See NOTES)	X		X		X	
Remotely Operated, Latching (See NOTES)	X		X		X	
Remotely Operated, Fail-Safe (See NOTES)		X		X	X	
Manually Operated (See NOTES)	X		X			X
28 VDC Drive Voltage	X	X	X	X	X	
110 VDC Drive Voltage	X		X			
115 VAC Drive Voltage	X		X			
Type N Connectors	X	X	X			X
Type SMA Connectors	X	X	X	X	X	X
Type TNC Connectors	X	X	X			X
Type BNC Connectors	X	X	X			X
Type HN Connectors	X	X	X			
Type C Connectors	X	X	X			
Upper Frequency Limit, GHz	12	2.5	8	20	20	5
Average Power at 1 GHz, KW	1.0	0.5	1.0	0.2	0.2	0.5
Product data starts on catalog page	44	48	50	53	55	58

NOTES:

Remote, Normally Open, Fail-Safe ... desired circuit completed only when drive voltage is applied ... no circuits closed in absence of drive voltage

Remote, Normally Closed, Fail-Safe ... with no drive voltage applied, one RF circuit is completed (this is the fail-safe position) ... when drive voltage is applied, the fail-safe circuit is opened and a new circuit is completed

Remote, Latching ... requires drive power only during the switching time ... switch remains in last selected position until a new position is selected

Manual ... operated by means of a knob or toggle ... by nature, it is a latching switch

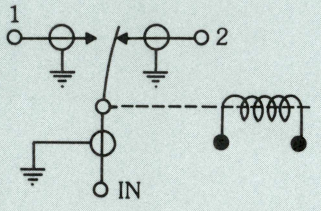
Indicator Light Circuits ... isolated circuits which are provided for interconnection of RF position indicator lamps, or for whatever purposes the user may have

Upper frequency limits... per above table or MIL-C-39012, whichever is lower

POPULAR CONTACT ARRANGEMENTS & SWITCHING ACTIONS

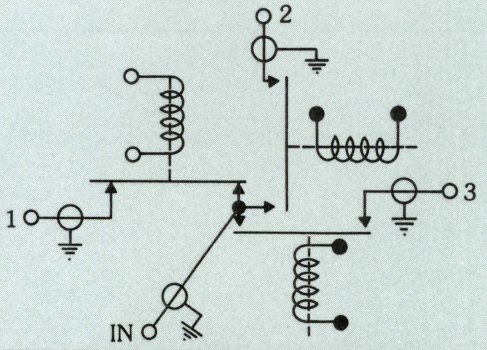
SINGLE-POLE DOUBLE-THROW (SPDT)

A three-terminal switch that connects one terminal to either of two other terminals



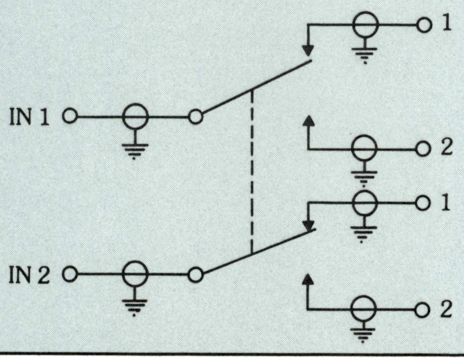
SINGLE-POLE MULTIPLE-THROW

A multiple-terminal switch that connects one terminal to any of several other terminals



DOUBLE-POLE DOUBLE-THROW (DPDT)

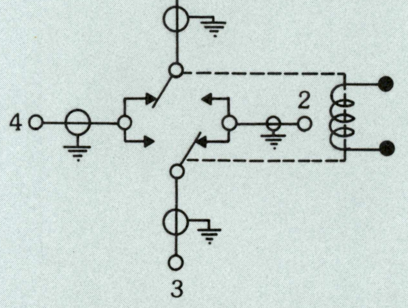
A six terminal switch that connects one pair of terminals to either of two other pairs of terminals


1
IN 1
2
1
IN 2
2

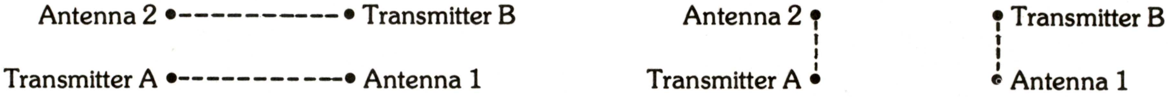
TRANSFER OR CROSSOVER

A reversing type switch that accomodates two independent signal paths through two isolated sets of connectors

(See note below)



NOTE. Transfer Switches are used to effect two-circuit transfers, such as reversing two transmitters with two antennas. This method of switching is illustrated below.


Antenna 2
Transmitter B
Transmitter A
Antenna 1
Antenna 2
Transmitter B
Transmitter A
Antenna 1

In the same manner, transfer switches are also used to add and remove filters and attenuators in RF signal paths.

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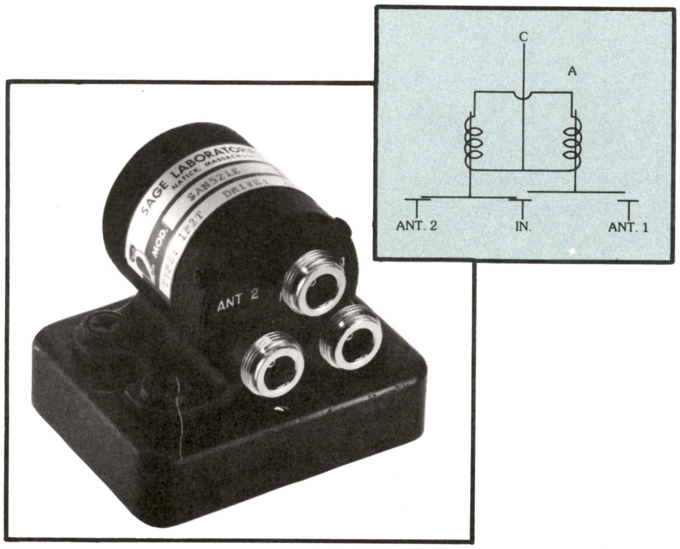
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL ELECTROMECHANICAL SWITCHES

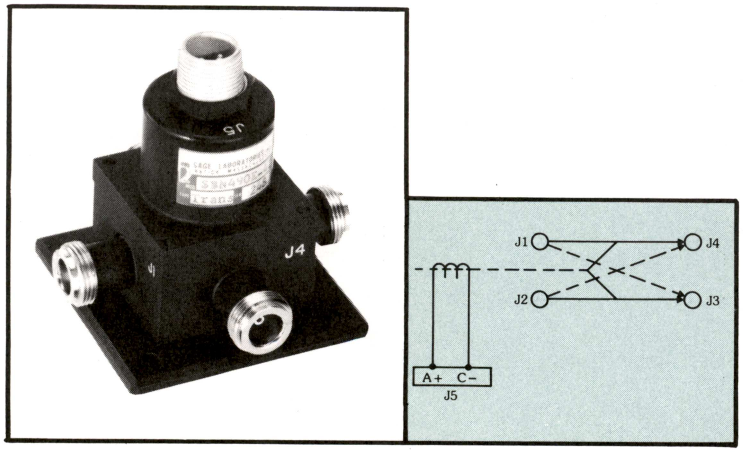
Since 1955, Sage Laboratories has developed special switch designs for applications ranging from underseas to deep space. A few of the unclassified custom designs are shown here.

TACAN ANTENNA SELECTOR SWITCH



This SPDT remotely controlled switch maintains an insertion loss of less than 0.2 dB from DC to 4 GHz, and has a minimum life expectancy of 1 million operations. Switching time is 0.01 seconds (10 milliseconds) maximum. Power handling capability is 50 watts CW; 3 kilowatts peak. The unit is hermetically sealed.

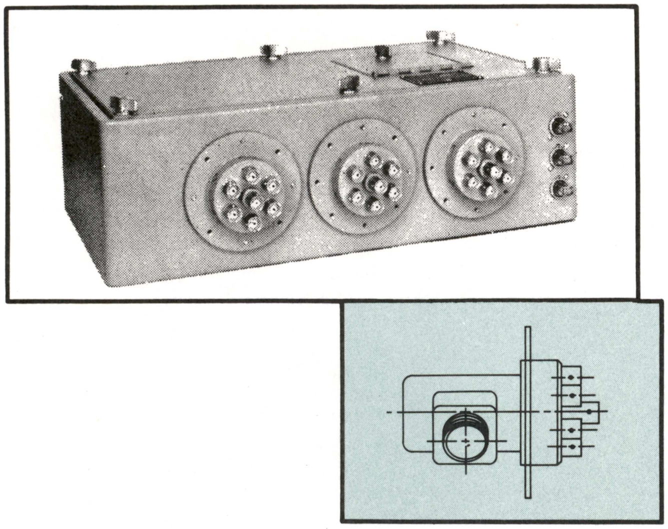
REMOTE FAIL-SAFE TRANSFER SWITCH WITH MOUNTING PLATE & POWER CONNECTOR



Designed for DC-2.5 GHz operation, this fail-safe transfer switch features 1 million cycle life, 0.2 dB maximum insertion loss, and 40 dB minimum isolation. Power capability is 500 watts CW; 4 kilowatts peak. Switching time is 10 milliseconds maximum, and the maximum drive current at 28 VDC is only 160 milliamperes. Duty cycle is continuous. The unit operates over a -54°C to +85°C temperature range.

CUSTOM ENGINEERING CAPABILITIES COAXIAL ELECTROMECHANICAL SWITCHES
(Continued)

HIGH SHOCK SUBMARINE ANTENNA SWITCHING ASSEMBLY

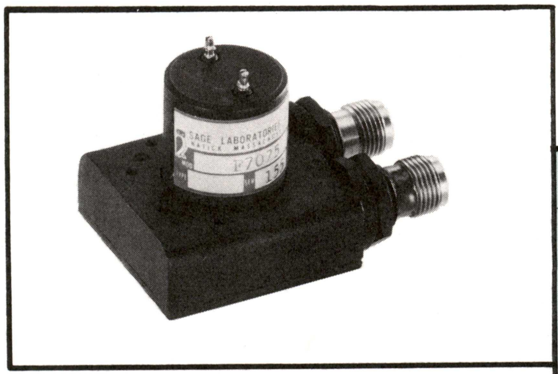


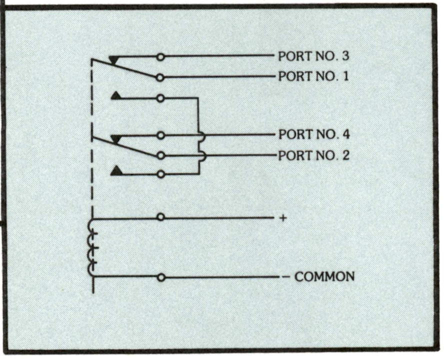
Designed for submarine operation, this assembly contains six remotely controlled 1P6T switches which can withstand depth charge induced shock. The assembly is used to interconnect various antennas and transmitters, and features a transmitter enabling provision. Isolation is greater than 60 dB. The accompanying drawing shows details of one of the switches used in the assembly.

DUAL SWITCHING PANELS FOR SHIPBOARD APPLICATION

The photograph shows technicians adding the finishing touches to a shipment of dual switching panels designed for a shipboard application.

CUSTOM ENGINEERING CAPABILITIES
COAXIAL ELECTROMECHANICAL SWITCHES
(Continued)



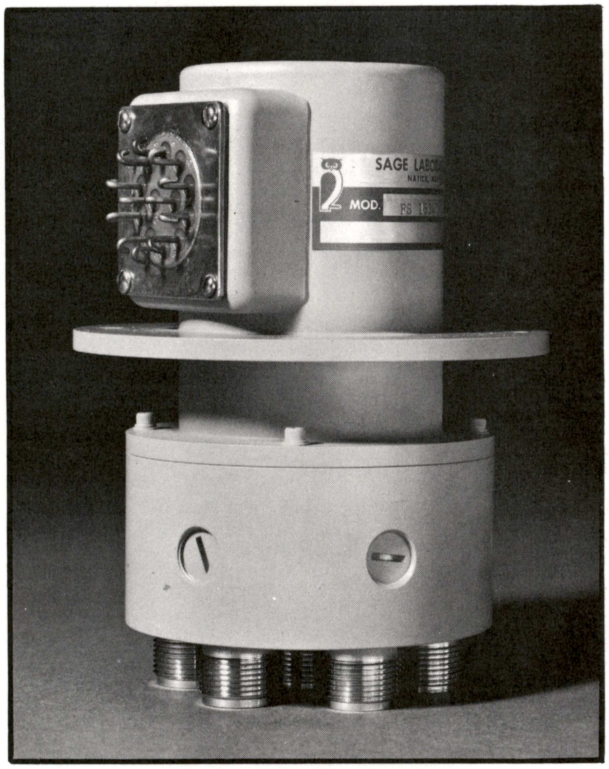


DPDT ALTIMETER SWITCH

This remotely operated DPDT coaxial switch was developed for altimeter operation from 4200-4400 MHz. The unit is hermetically sealed, and operates from a 100-124 VAC (400 Hz) solenoid drive supply. Switching time is 20 milliseconds maximum, and duty cycle is continuous. Input power handling capability is 2 KW peak at a 0.003 duty cycle. Maximum insertion loss is 1.0 dB (energized) and 0.5 dB (de-energized). Isolation is 56 dB minimum, and maximum allowable VSWR over the 4200-4400 MHz operating range was 1.35. The weight of the unit is only 5.5 ounces, and the switch meets all applicable vibration, shock, humidity, thermal shock, and salt spray requirements of MIL-STD-202. Minimum life expectancy is 1,000,000 (1 million) cycles.

Your custom engineering inquiries are cordially invited.

CUSTOM ENGINEERING CAPABILITIES
COAXIAL ELECTROMECHANICAL SWITCHES (Continued)



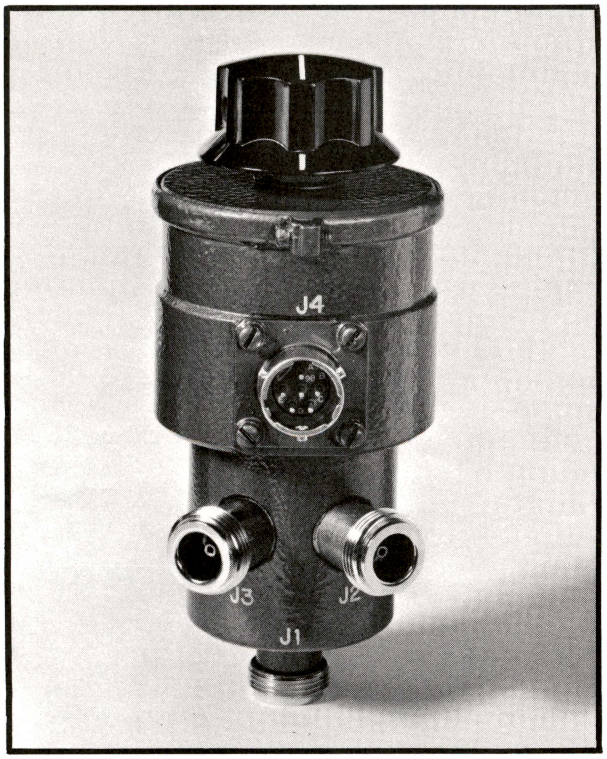
RUGGED 2-32 MHz SWITCH FEATURES 5 KW POWER HANDLING CAPABILITY

Model FS-1524 provides a 5 KW (CW) power handling capability from 2-32 MHz. Type HN connectors are used. Construction is of the type used for depth-charge-proof submarine switch assemblies supplied by Sage to other customers. VSWR is 1.1:1 maximum (1.05:1 typical). Insertion loss is 0.1 dB maximum (0.02 dB typical). Isolation is 60 dB minimum (100 dB typical from 2-32 MHz - 60 dB minimum at 100 MHz).

The particular version shown at left operates on a coil voltage of 110-125 VDC or VAC. Switching rate is 20 operations per minute in this application. Switching time is 50 milliseconds per 60 degrees of throw.

The minimum life specification was 50,000 operations. Operating temperature range was −28°C to +65°C.

An indicator light circuit is built in.



SPECIAL MANUAL SELECTOR SWITCH FEATURES INDICATOR LIGHT CIRCUIT

Model FS-2192 is a single-pole double-throw (SPDT) manual selector switch which has essentially the same operating characteristics as our standard SA Series switches. It is unusual in that it features an indicator light circuit, which the customer required for this particular application.

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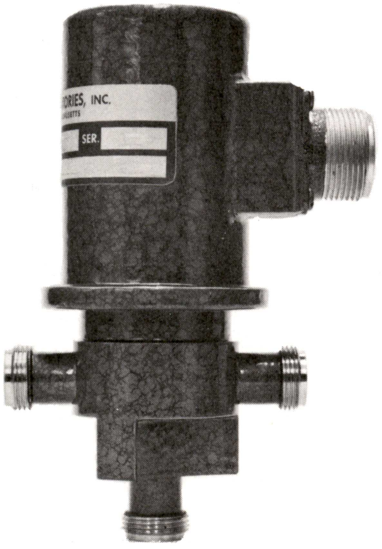
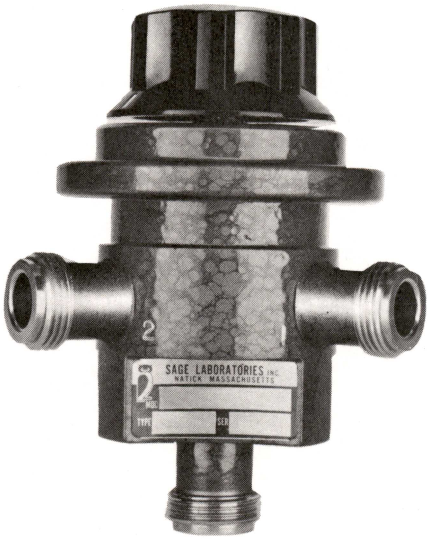
SA SERIES

RADIAL TYPE MULTI-THROW ELECTROMECHANICAL COAXIAL SWITCHES (MANUAL & REMOTE MODELS)



FEATURES

COMMON
- single-pole multi-throw
- DC-12 GHz operating frequency range
- medium to high power handling capability
- low loss
- high isolation
- six (6) standard RF connector types
- all models meet applicable requirements of MIL-S-3928C



REMOTE
- rotary solenoid actuation
- latching action
- self de-energizing
- indicator light circuit available at no extra cost

MANUAL
- positive ball bearing detent
- panel or base mounting provisions

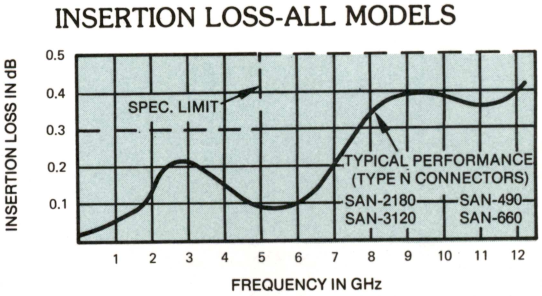
ELECTRICAL SPECIFICATIONS

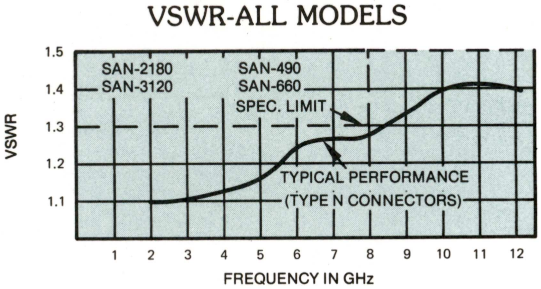
RF SPECIFICATIONS (N CONNECTORS)

Frequency Range			DC-12 GHz
Maximum VSWR		1.3	DC-8 GHz
		1.5	8-12 GHz
Maximum Insertion Loss		0.3 dB	DC-5 GHz
		0.5 dB	5-12 GHz
Isolation	average	70 dB	DC-12 GHz
	minimum	50 dB	DC-12 GHz
	(40 dB min. between adjacent 60° positions) (50 dB for 90° or greater)		
Average Power Capability		3.0 KW	DC-0.1 GHz
		1.0 KW	DC-1 GHz
		300 W	DC-10 GHz
RF Voltage Rating		1500V	

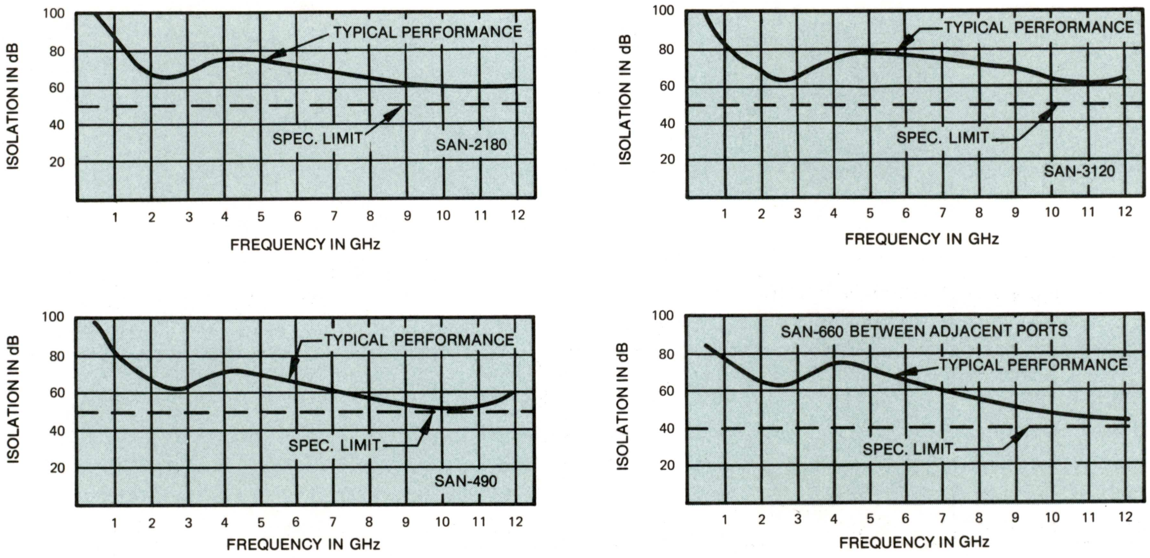
NOTE: Derate RF voltage with altitude in accordance with SMA connector ratings if SMA connectors are used. Otherwise, derate in accordance with type N connector ratings.

SA SERIES ELECTRICAL SPECIFICATIONS (continued)





ISOLATION FOR VARIOUS PORT CONFIGURATIONS



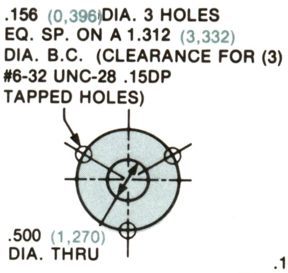
ELECTRICAL DRIVE REQUIREMENTS

CODE	VOLTAGE RANGE	NOMINAL VOLTAGE	MAXIMUM SURGE CURRENT (AT NOMINAL VOLTAGE & ROOM TEMPERATURE)
E	24-32 VDC	28 VDC	2.2 AMPS
G	100-120 VDC	110 VDC	0.7 AMPS
H	105-125 VAC	115 VAC	0.7 AMPS

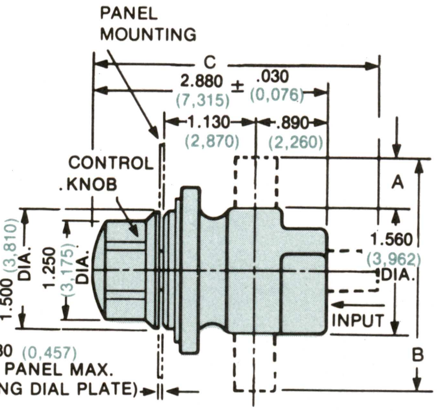
NOTE: Holding current of fail-safe unit is normally one-fourth of switching surge current. Suffix FS at end of model number indicates normally closed Fail-Safe. Available only for 2-position 28VDC and 115VAC units.

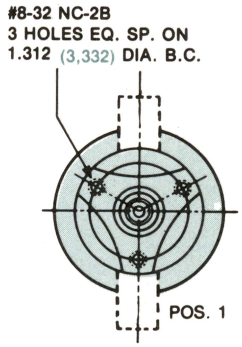
SA SERIES-MECHANICAL DATA

MANUAL


.156 (0,396) DIA. 3 HOLES
EQ. SP. ON A 1.312 (3,332)
DIA. B.C. (CLEARANCE FOR (3)
#6-32 UNC-28 .15DP
TAPPED HOLES)
.500 (1,270)
DIA. THRU

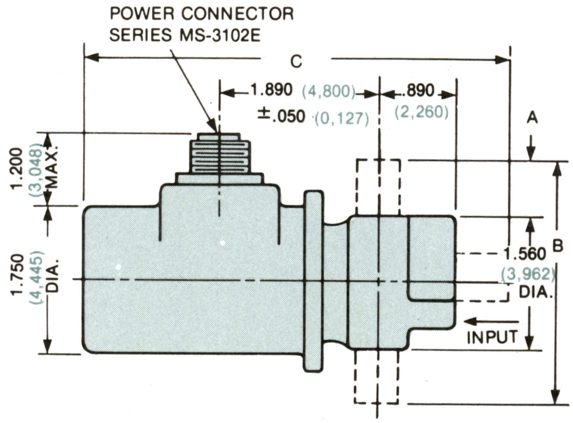
(PANEL MOUNTING)

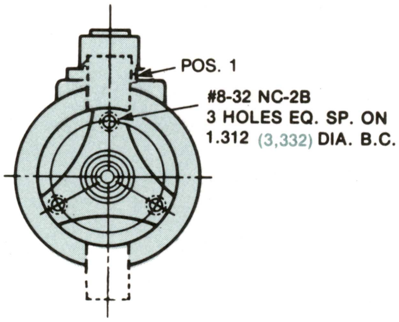

PANEL
MOUNTING
C
2.880 ± .030
(7,315) (0,076)
1.130 (2,870)
.890 (2,260)
CONTROL
KNOB
1.500 (3,810) DIA.
1.250 (3,175) DIA.
A
1.560 (3,962) DIA.
INPUT
B
.180 (0,457)
THICK PANEL MAX.
(EXCLUDING DIAL PLATE)


#8-32 NC-2B
3 HOLES EQ. SP. ON
1.312 (3,332) DIA. B.C.
POS. 1

(BASE MOUNTING)

REMOTE


POWER CONNECTOR
SERIES MS-3102E
C
1.890 (4,800)
±.050 (0,127)
.890 (2,260)
A
1.200 (3,048) MAX.
1.750 (4,445) DIA.
1.560 (3,962) DIA.
B
INPUT


POS. 1
#8-32 NC-2B
3 HOLES EQ. SP. ON
1.312 (3,332) DIA. B.C.

CONNECTOR TYPE		MODEL NUMBER PREFIX	DIMENSIONS			
					MANUAL	REMOTE
			A ± 0.02	B ± 0.03	C ± 0.03	C ± 0.03
N	Female	SAN-	.610 (1,549)	2.780 (7,061)	3.490 (8,864)	5.070 (12,877)
TNC	Female	SAT-	.480 (1,219)	2.530 (6,426)	3.360 (8,534)	4.940 (12,547)
BNC	Female	SAB-	.480 (1,219)	2.530 (6,426)	3.360 (8,534)	4.940 (12,547)
C	Female	SAC-	.530 (1,346)	2.630 (6,680)	3.410 (8,661)	4.990 (12,674)
HN	Female	SAH-	.610 (1,549)	2.780 (7,061)	3.490 (8,864)	5.070 (12,877)
SMA	Female	SAM-	.350 (0,889)	2.260 (5,740)	3.230 (8,204)	4.790 (12,166)

PHYSICAL CHARACTERISTICS

	MANUAL	REMOTE
Minimum Life	100,000 operations	100,000 operations
Temperature Range	-60°C to +100°C	-60°C to +100°C
RF Positions (See overleaf)	2 to 6	2 to 6
Switching Time		50 milliseconds/60° of throw
Switching Rate		30 operations per minute
Weight (depending on RF positions)	7 to 9 ounces	14 to 20 ounces

MATERIALS & FINISHES

Bodies: aluminum (painted Sage Hammertone Green)

Coax Contacts: beryllium, gold-plated

Connectors: brass, chrome-plated or aluminum or passivated stainless steel

All SageLine materials & finishes to government specs

Alternative materials & finishes on special order

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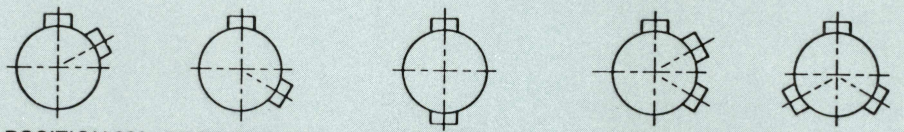
STANDARD RF CONNECTOR CONFIGURATIONS
SA SERIES

MANUAL SWITCHES

ORDERING CODE

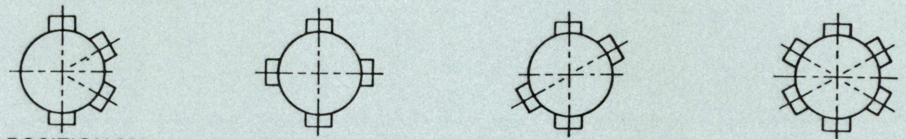
SA N 2 180

Series
1st Letter of Connector Type
Number of Positions
Degrees of Angle Between Positions



2 POSITION 60° 2 POSITION 120° 2 POSITION 180° 3 POSITION 60° 3 POSITION 120°

STANDARD OUTPUT CONFIGURATIONS
AS VIEWED FROM KNOB END



4 POSITION 60° 4 POSITION 90° 4 POSITION 60/120° 6 POSITION 60°

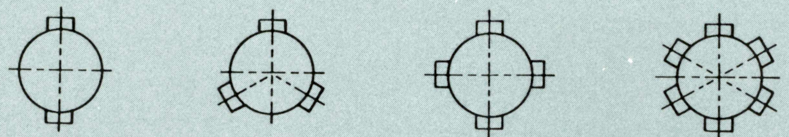
REMOTE CONTROL SWITCHES

ORDERING CODE

SA N 2 180 E

Series
1st Letter of Connector Type
Number of Positions
Degrees of Angle Between Positions
Drive Voltage Code (Add L Suffix for Indicator Light Circuit)

SUFFIX FS INDICATES NORMALLY CLOSED FAIL-SAFE (2-POSITION 28VDC OR 115VAC)



2 POSITION 180° 3 POSITION 120° 4 POSITION 90° 6 POSITION 60°

STANDARD REMOTE CONTROL OUTPUT CONFIGURATIONS

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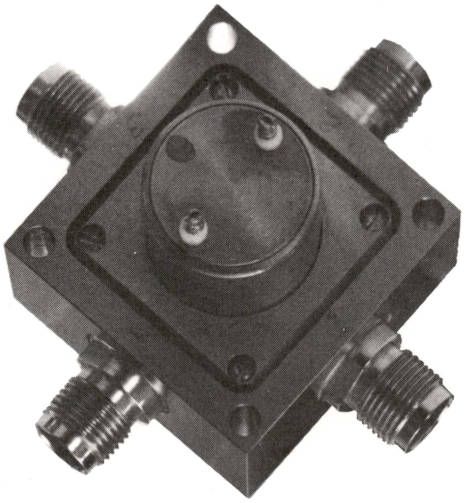
SB SERIES

FAIL-SAFE TRANSFER (CROSS-OVER) ELECTROMECHANICAL COAXIAL SWITCHES (REMOTELY OPERATED MODELS ONLY)

FEATURES

- DC-2.5 GHz frequency range
- low drive current
- million cycle life
- low insertion loss (typically 0.1 dB)
- high isolation (typically 50 dB)
- choice of 6 RF connector types
- DPDT transfer or cross-over operation (when de-energized, switch connects J1 to J4 and J2 to J3 ... when energized, switch connects J1 to J3 and J2 to J4)

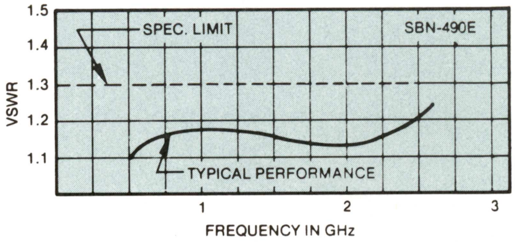


ELECTRICAL SPECIFICATIONS

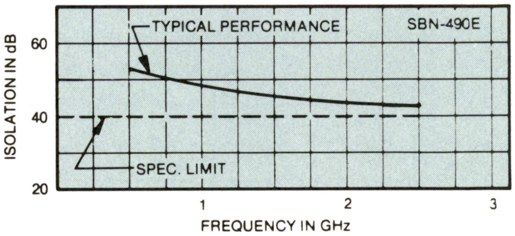
- Frequency Range: DC-2.5 GHz
- VSWR: 1.3 maximum
- Insertion Loss: 0.2 dB maximum
- Isolation: 40 dB minimum
- Power Capability: 500 watts CW at 1 GHz
  4 KW peak at one
  atmosphere pressure

- Solenoid Input Requirements:
  Drive Voltage Range: 24-32 VDC
  Nominal Drive Voltage: 28 VDC*
  Maximum Current
  (at 20°C and 28 VDC): 160 milliamperes

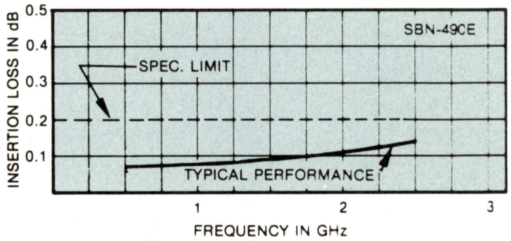
*12 VDC drive available



VSWR

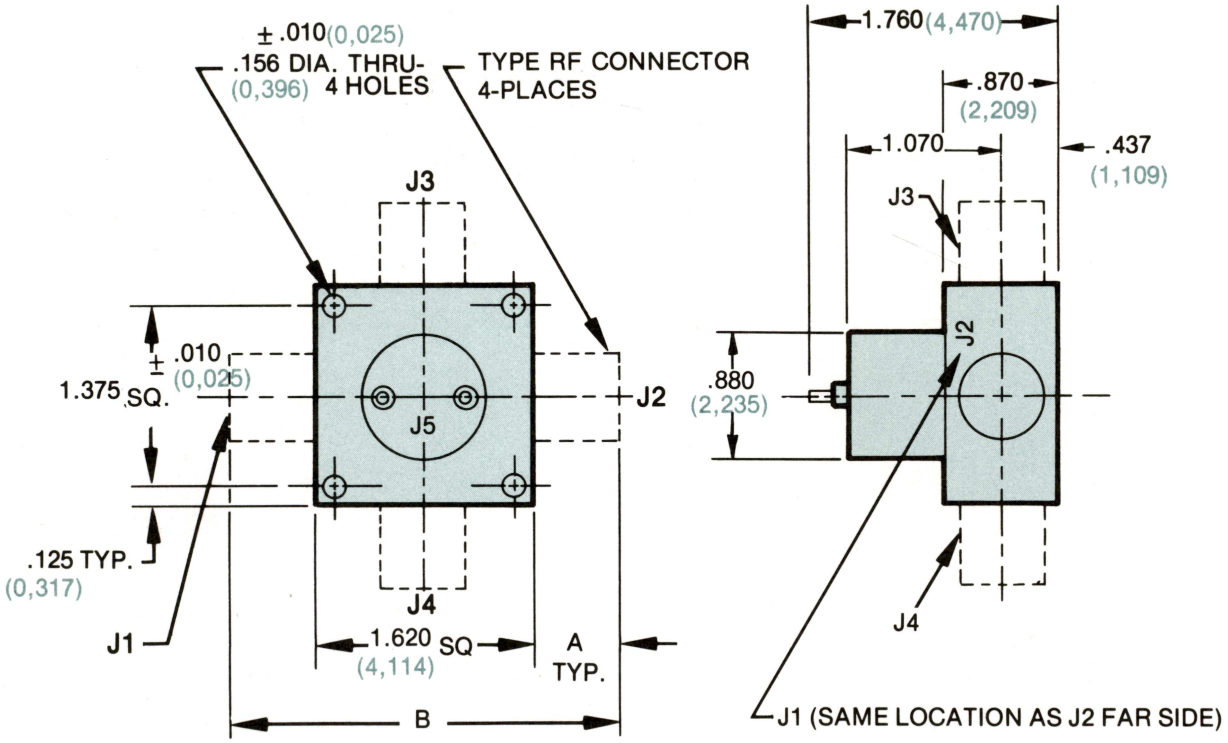


ISOLATION



INSERTION LOSS

MECHANICAL DATA
SB SERIES



± .010(0,025)
.156 DIA. THRU-
(0,396) 4 HOLES
TYPE RF CONNECTOR
4-PLACES
J3
± .010
(0,025)
1.375 SQ.
J5
J2
.125 TYP.
(0,317)
J4
J1
1.620 SQ
(4,114)
A
TYP.
B
1.760(4,470)
.870
(2,209)
1.070
.437
(1,109)
J3
J2
.880
(2,235)
J4
J1 (SAME LOCATION AS J2 FAR SIDE)

MODEL	CONNECTOR	DIMENSION A	DIMENSION B ± .03
SBN -490E	N	.650 (1,651)	2.920 (7,416)
SBH -490E	HN	.650 (1,651)	2.920 (7,416)
SBB -490E	BNC	.520 (1,320)	2.660 (6,756)
SBT -490E	TNC	.520 (1,320)	2.660 (6,756)
SBC -490E	C	.560 (1,422)	2.750 (6,985)
SBM -490E	SMA	.380 (0,965)	2.380 (6,045)

PHYSICAL CHARACTERISTICS

Switching Time — 10 milliseconds MAX.
Duty Cycle — continuous
Minimum Life — 1 Million cycles

Temperature Range — −54°C to + 85°C
Available Connector Types — Female N, TNC, BNC, HN, C, and SMA
Weight — 5 ounces with Type N connectors

MATERIALS & FINISHES

Bodies:	aluminum (Electroless Nickel)
Coax Contacts:	beryllium, gold-plated
Connectors:	brass, chrome-plated or aluminum or passivated stainless steel

All SageLine materials & finishes to government specs
Alternative materials & finishes on special order

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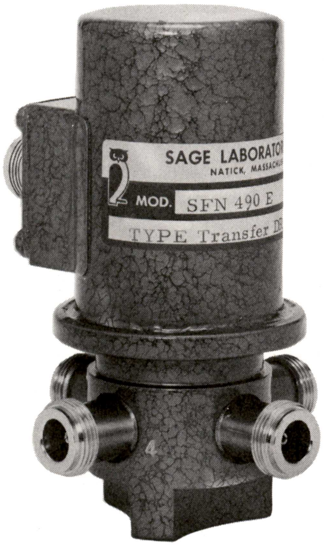
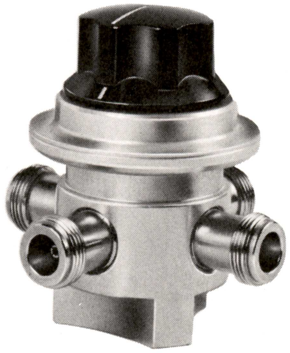
SF SERIES

RADIAL TRANSFER (CROSS-OVER) ELECTROMECHANICAL COAXIAL SWITCHES (MANUAL & REMOTE MODELS)



FEATURES

COMMON
- Dc-8 GHz operating frequency range
- low insertion loss
- high isolation
- medium to high power handling capability
- six (6) standard RF connector types
- all models meet applicable requirements of MIL-S-3928C



REMOTE
- latching action
- rotary solenoid actuation
- self de-energizing
- indicator light circuit available at no extra cost

MANUAL
- positive ball bearing detent
- panel or base mounting provisions

ORDERING CODE

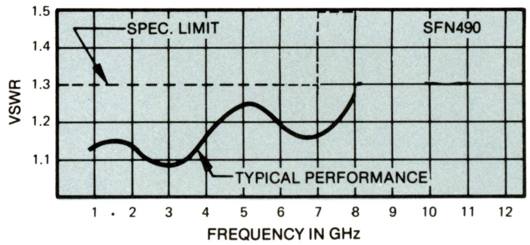
Series	SF
1st Letter of Connector Type	T
Identifying Number	490
Drive Voltage Code*	E
Indicator Light Designation*	L

*Does not apply to manual switches

SOLENOID INPUT REQUIREMENTS

CODE	DRIVE VOLTAGE RANGE	NOMINAL DRIVE VOLTAGE	MAXIMUM SURGE CURRENT
E	24-32 VDC	28 VDC	2.2 AMPS
F	44-52 VDC	48 VDC	1.5 AMPS
G	100-120 VDC	110 VDC	0.7 AMPS
H	105-125 VAC	115 VAC	0.7 AMPS

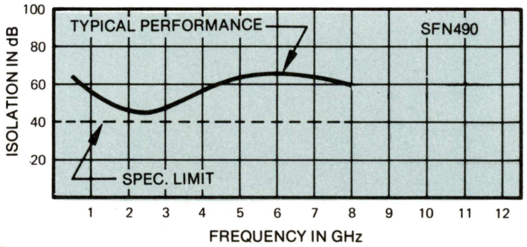
SF SERIES ELECTRICAL SPECIFICATIONS



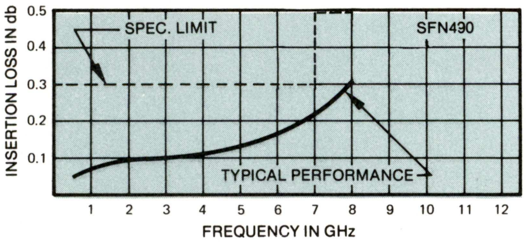
VSWR

RF SPECIFICATIONS (N CONNECTORS)

Frequency Range		DC-8 GHz
Maximum VSWR	1.3	DC-7 GHz (<1.5 to 8 GHz)
Insertion Loss	<0.3 dB	DC-7 GHz (<0.5 dB to 8 GHz)
Isolation		>40 dB
Average Power Capability	3.0 KW	DC-0.1 GHz
	1.0 KW	DC-1 GHz
	350 W	DC-8 GHz



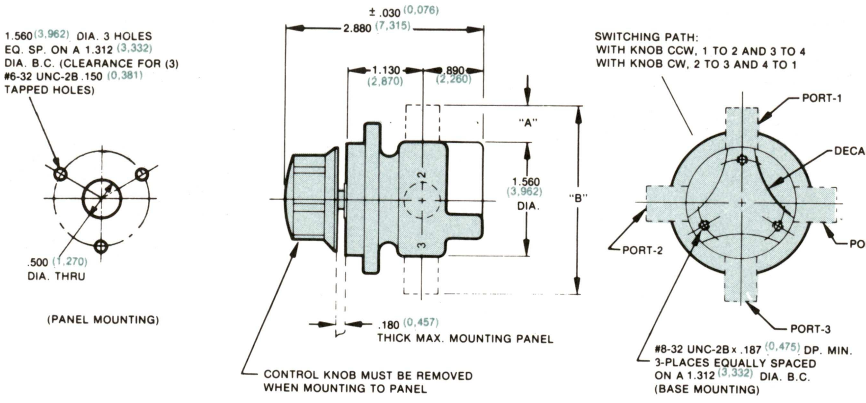
ISOLATION



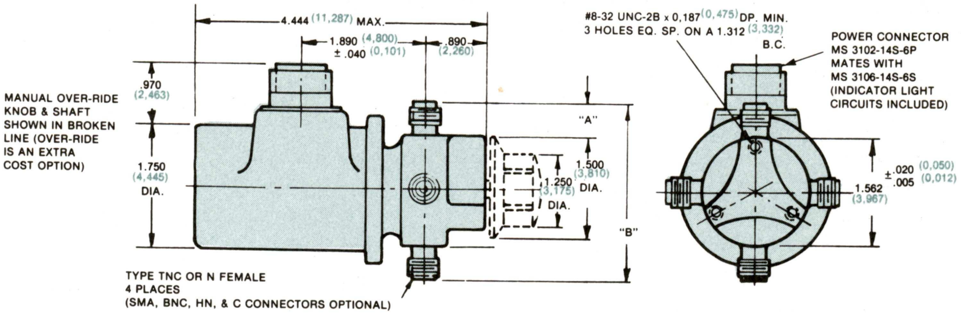
INSERTION LOSS

SF SERIES-MECHANICAL DATA

MANUAL


1.560 (3,962) DIA. 3 HOLES EQ. SP. ON A 1.312 (3,332) DIA. B.C. (CLEARANCE FOR (3) #6-32 UNC-2B .150 (0,381) TAPPED HOLES)
.500 (1,270) DIA. THRU
(PANEL MOUNTING)
± .030 (0,076)
2.880 (7,315)
1.130 (2,870)
.890 (2,260)
2
3
"A"
1.560 (3,962) DIA.
"B"
.180 (0,457) THICK MAX. MOUNTING PANEL
CONTROL KNOB MUST BE REMOVED WHEN MOUNTING TO PANEL
SWITCHING PATH:
WITH KNOB CCW, 1 TO 2 AND 3 TO 4
WITH KNOB CW, 2 TO 3 AND 4 TO 1
PORT-1
DECAL
PORT-2
PORT-4
PORT-3
#8-32 UNC-2B x .187 (0,475) DP. MIN. 3-PLACES EQUALLY SPACED ON A 1.312 (3,332) DIA. B.C. (BASE MOUNTING)

REMOTE


4.444 (11,287) MAX.
1.890 (4,800) ± .040 (0,101)
.890 (2,260)
MANUAL OVER-RIDE KNOB & SHAFT SHOWN IN BROKEN LINE (OVER-RIDE IS AN EXTRA COST OPTION)
.970 (2,463)
1.750 (4,445) DIA.
"A"
1.500 (3,810) DIA.
1.250 (3,175) DIA.
"B"
TYPE TNC OR N FEMALE 4 PLACES (SMA, BNC, HN, & C CONNECTORS OPTIONAL)
#8-32 UNC-2B x 0,187 (0,475) DP. MIN. 3 HOLES EQ. SP. ON A 1.312 (3,332) B.C.
POWER CONNECTOR MS 3102-14S-6P MATES WITH MS 3106-14S-6S (INDICATOR LIGHT CIRCUITS INCLUDED)
1.562 (3,967)
± .020 (0,050) .005 (0,012)

MODEL	CONNECTORS*	DIMENSIONS	
		"A" ± 0.02	"B" ± 0.03
SFM 490	Type SMA	.350 (0,889)	2.260 (5,740)
SFH 490	Type HN	.610 (1,549)	2.780 (7,061)
SFC 490	Type C	.530 (1,346)	2.630 (6,680)
SFT 490	Type TNC	.480 (1,219)	2.530 (6,426)
SFB 490	Type BNC	.480 (1,219)	2.530 (6,426)
SFN 490	Type N	.610 (1,549)	2.780 (7,061)

*Electrical performance & weight will be affected by choice of connectors

PHYSICAL CHARACTERISTICS

	MANUAL	REMOTE
Minimum Life	100,000 operations	100,000 operations
Temperature Range	-60°C to +100°C	-60°C to +100°C
Switching Time		75 milliseconds
Switching Rate		30 operations per minut
Weight (with type N connectors)	9 ounces	20 ounces

MATERIALS & FINISHES

Bodies: aluminum (painted Sage
Hammertone Green)
Coax Contacts: beryllium, gold-plated
Connectors: brass, chrome plated or
aluminum or passivated
stainless steel

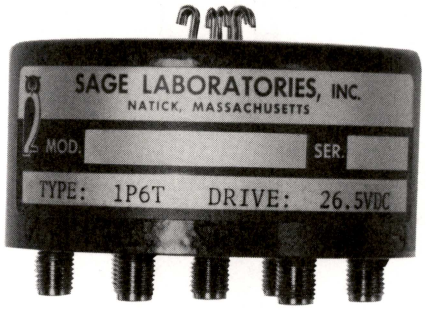
All SageLine materials & finishes
to government specs
Alternative materials & finishes
on special order

sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

SHM SERIES FAIL-SAFE MULTI-THROW ELECTROMECHANICAL COAXIAL SWITCHES (REMOTELY CONTROLLED)

FEATURES

- DC to 18 GHz operating frequency range
- low loss
- better than 60 dB isolation
- compact configuration
- choice of 3 through 6 positions
- SMA connectors
- meet applicable requirements of MIL-S-3928B
- fail-safe to normally open, all ports



ELECTRICAL SPECIFICATIONS

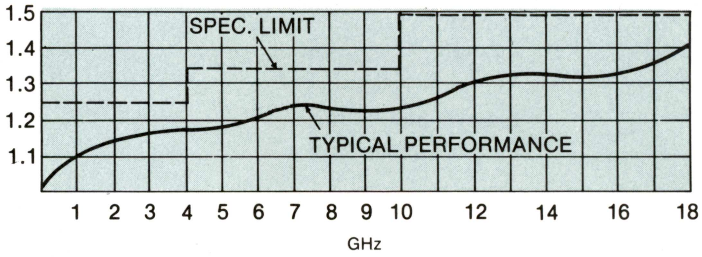
RF CONTACT RATINGS

- Frequency Range: DC-18 GHz
- Maximum VSWR: 1.25........DC-4 GHz
  (See curve) 1.35........ 4-10 GHz
  1.50....... 10-18 GHz
- Maximum Insertion Loss:
  (See curve) 0.3 dB..... DC-7 GHz
  0.4 dB... 7-12.4 GHz
  0.5 dB..12.4-18 GHz
- Minimum Isolation: 60 dB
- Average Power: 200 watts maximum at 1 GHz* & room ambient
- Peak Power: 1.5 KW maximum (Derate with altitude)*
- Characteristic Impedence: 50 ohms
- Maximum Voltage: 350 volts rms

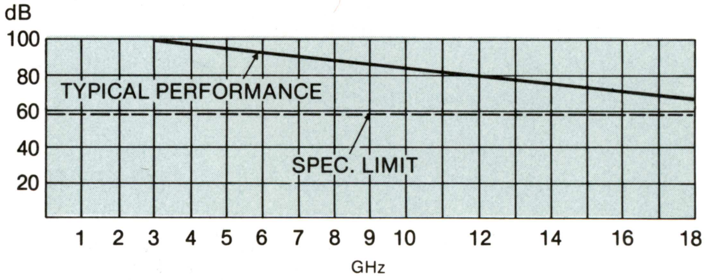
SOLENOID INPUT REQUIREMENTS

- Drive Voltage Range: 20-30 VDC
- Maximum Current (at room ambient & 28 VDC): 0.13 Amps (Coil Resistance: 265 ± 15 ohms)

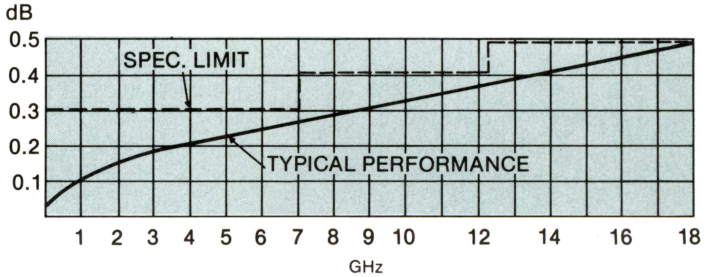
* Hot switching (with RF power applied) is possible at ¼ cold switching rated power if the solenoid drive circuits provide make-before-break action.



VSWR



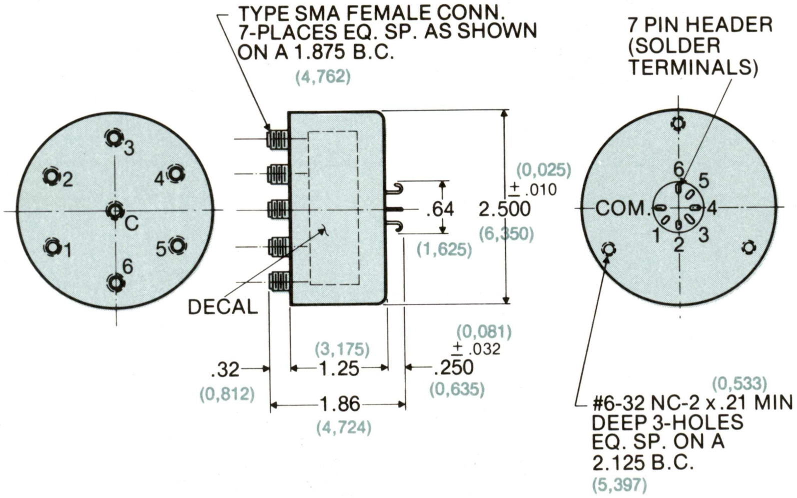
ISOLATION



INSERTION LOSS

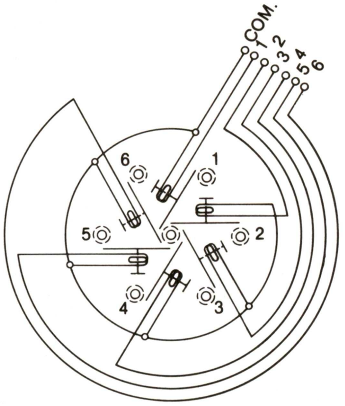
SHM SERIES - MECHANICAL DATA

OUTLINE DRAWINGS



TYPE SMA FEMALE CONN.
7-PLACES EQ. SP. AS SHOWN
ON A 1.875 B.C.
(4,762)
3
2
4
C
1
5
6
DECAL
(0,025)
± .010
.64
2.500
(6,350)
(1,625)
(0,081)
± .032
.32
(0,812)
(3,175)
1.25
.250
(0,635)
1.86
(4,724)
7 PIN HEADER
(SOLDER
TERMINALS)
COM.
6
5
4
1
2
3
(0,533)
#6-32 NC-2 x .21 MIN
DEEP 3-HOLES
EQ. SP. ON A
2.125 B.C.
(5,397)

SCHEMATIC
(SHOWN WITH ALL
POSITIONS DE-ENERGIZED)



COM.
1
2
3
4
5
6
6
1
5
2
4
3

PHYSICAL CHARACTERISTICS

Number of Positions	3 to 6
Actuation	Fail-Safe to normally open, all ports
Maximum Switching Time	20 Milliseconds
Minimum Life, each position	1,000,000 cycles
Ambient Temperature Range	−55 to +85°C
Maximum Weight	8 ounces
Maximum Altitude	50,000 feet
Power Connections	solder terminals

MATERIALS & FINISHES

Bodies (aluminum) and Covers (cadmium-plated steel): iridited & painted Sage Hammertone Green

Connectors: stainless steel, passivated

Coaxial Contacts: beryllium, gold-plated

All SageLine materials & finishes to Government Specs

Alternative materials & finishes on Special Order

HOW TO ORDER

SH M 3 120 E C

SERIES — SH

RF CONNECTORS — M
M — SMA FEMALE

NUMBER OF POSITIONS — 3

DEGREES BETWEEN CONNECTORS — 120
3 Pos. 120°
4 Pos. 60/120°
5 & 6 Pos. 60°

ACTUATION VOLTAGE — E
E — 20-30 VDC

ACTUATION FEATURES — C
C — Fail Safe All Positions N.O.

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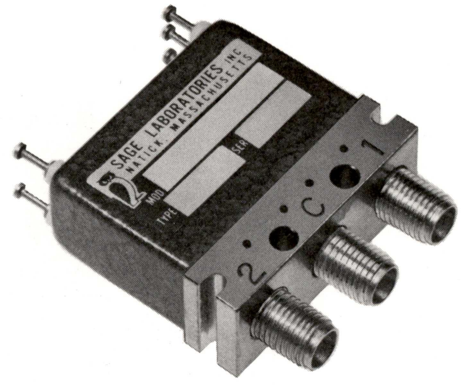
SK SERIES
SPDT MINIATURE ELECTROMECHANICAL COAXIAL SWITCHES (REMOTELY CONTROLLED)

FEATURES

- DC-20.5 GHz operating frequency range
- miniature
- low drive current
- million cycle life
- high isolation (typically 80 dB)
- switches can be stacked together
- indicator light circuit available at no extra cost
- fail-safe or latching


SAGE LABORATORIES INC
NATICK MASSACHUSETTS
MOD
TYPE
SER
1
C
2

ELECTRICAL SPECIFICATIONS

RF CONTACT RATINGS

- Frequency Range: DC-20.5 GHz
- Maximum VSWR: 1.2 .... DC-4 GHz
  1.25 .... 4-8 GHz
  1.4 ....8-12.4 GHz
  1.5 ....12.4-18 GHz
- Maximum Insertion Loss: 0.3 dB......... DC-11 GHz
  0.4 dB ....11-12.4 GHz
  0.5 dB........... 12.4-18 GHz
- Isolation: 60 dB minimum, DC-18 GHz
- Average Power: 200 watts maximum at 1 GHz & room ambient
- Peak Power: 1.5 KW maximum (Derate with altitude)

AUXILIARY CONTACT RATINGS (at 28 VDC)

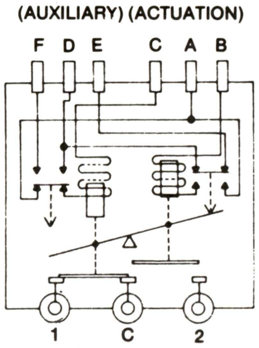
- 0.5 Amp maximum for 10^6 closures
- 2.0 Amps maximum for 10^5 closures

SOLENOID INPUT REQUIREMENTS

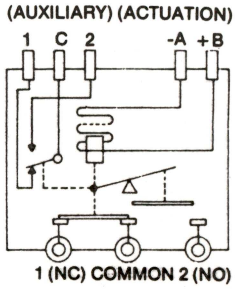
- Drive Voltage Range: 20-30 VDC
- Maximum Current (at room ambient & 28 VDC)
  Fail-Safe: 0.13 Amps (Pull-in and Hold)
  Latching: 0.6 Amp (momentary during switching only)

SCHEMATICS

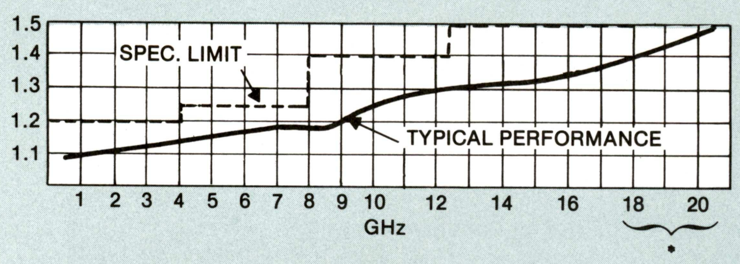
LATCHING


(AUXILIARY) (ACTUATION)
F D E C A B
1
C
2

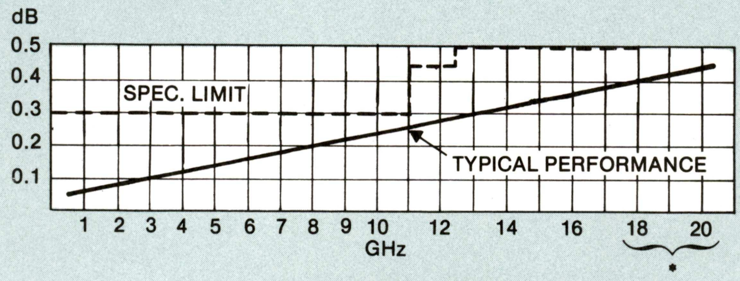
FAIL SAFE


(AUXILIARY) (ACTUATION)
1 C 2 -A +B
1 (NC) COMMON 2 (NO)

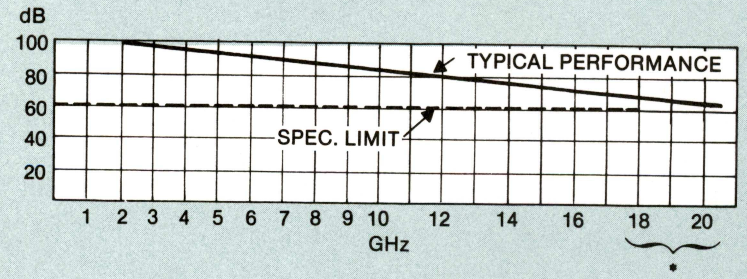
ELECTRICAL SPECIFICATIONS (continued)
SK SERIES



VSWR



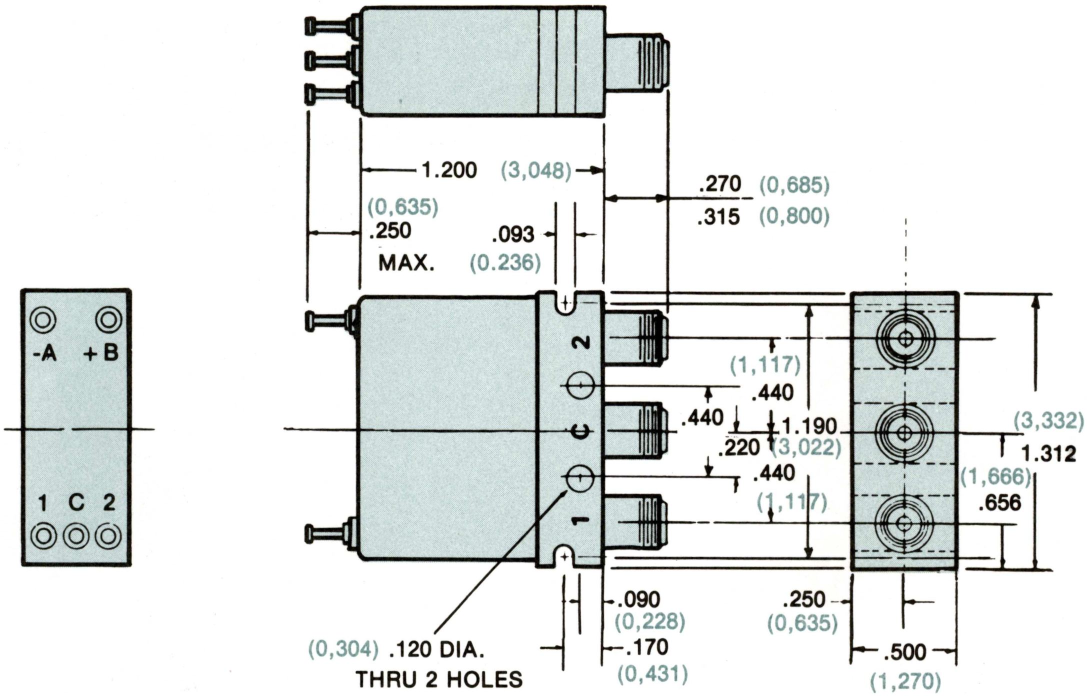
INSERTION LOSS



ISOLATION

*Tested to 18 GHz (standard)
Tested to 20.5 GHz (on special order only)

SK SERIES-MECHANICAL DATA



1.200 (3,048)
(0,635)
.250
MAX.
.093
(0.236)
.270 (0,685)
.315 (0,800)
-A
+B
1 C 2
2
C
1
(1,117)
.440
.440
.220
1.190
(3,022)
.440
(1,117)
(3,332)
1.312
(1,666)
.656
.090
(0,228)
.170
(0,431)
(0,304) .120 DIA.
THRU 2 HOLES
.250
(0,635)
.500
(1,270)

ORDERING INFORMATION

MODEL	ACTUATION
SKM/EA	Fail-safe to Position 1
SKM/EB	Fail-safe to Position 1 with SPDT auxiliary circuit
SKM/EE	External pulse latching (†)
SKM/EF	External pulse latching (†) with SPDT auxiliary circuit
SKM/EG	Latching, self-deenergized
SKM/EH	Latching self-deenergized with SPDT auxiliary circuit
	(†) 50-millisecond pulse to be supplied externally

PHYSICAL CHARACTERISTICS

Minimum Life	1,000,000 cycles
Ambient Temperature Range	-55°C to +85°C
Switching Time, maximum	20 milliseconds
Altitude, maximum	50,000 feet
Weight, maximum	1.5 ounces
Power Connections	solder terminals

MATERIALS & FINISHES

Bodies: aluminum-electroless nickel
Covers: iridited & painted Sage
Hammertone Green
RF Connectors: stainless steel-passivated

All SageLine materials & finishes to government specs
Alternate materials & finishes on special order

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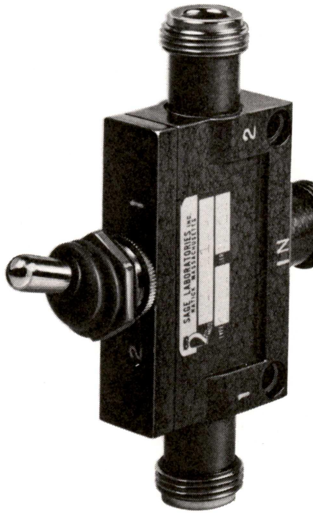
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

ST SERIES

SPDT TOGGLE TYPE MANUALLY OPERATED ELECTROMECHANICAL COAXIAL SWITCHES

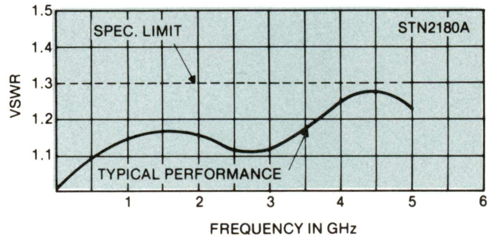
FEATURES

- DC-5 GHz frequency range
- low cost
- compact
- precious metal contacts
- can easily be ganged for multi-pole switching
- mechanically rugged
- long life
- meets applicable requirements of MIL-S-3928B

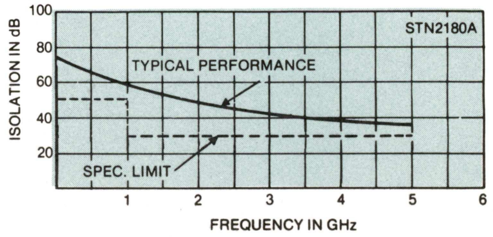


ELECTRICAL SPECIFICATIONS (FOR ALL CONNECTOR TYPES)

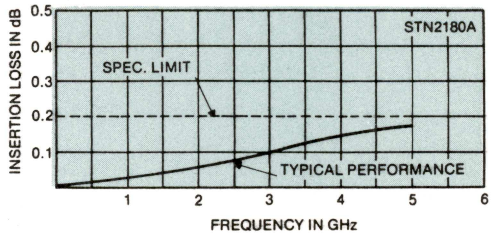
- Frequency Range: ....DC-5 GHz
- Maximum VSWR: 1.3
- Insertion Loss: ....< 0.2 dB
- Isolation: ....>50 dB DC-1.0 GHz
  (> 30 dB to 5 GHz)
- Power Capability: .... 50 Watts Average
  2.5 KW Peak



VSWR

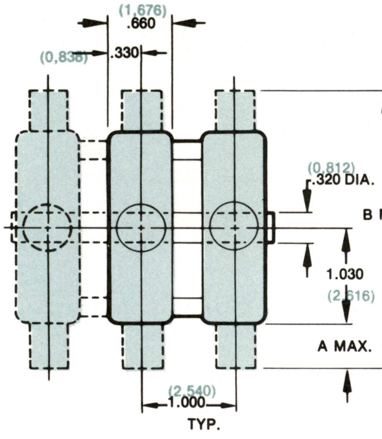


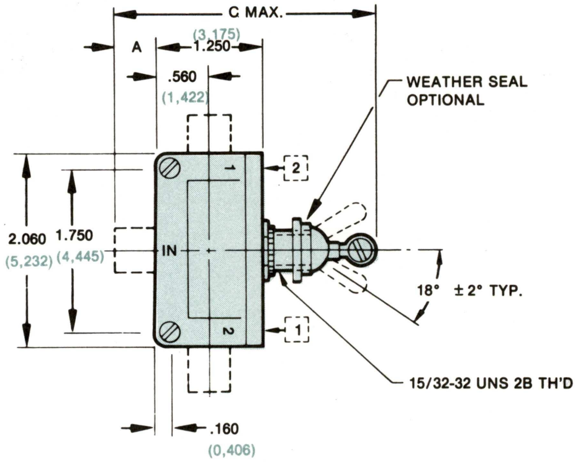
ISOLATION



INSERTION LOSS

ST SERIES - MECHANICAL DATA


(1,676)
.660
(0,838)
.330
(0,812)
.320 DIA.
B MAX.
1.030
(2,616)
A MAX.
(2,540)
1.000
TYP.


C MAX.
A
(3,175)
1.250
.560
(1,422)
WEATHER SEAL OPTIONAL
2
1
IN
2.060
(5,232)
1.750
(4,445)
18° ±2° TYP.
1
2
15/32-32 UNS 2B TH'D
.160
(0,406)

NOTE: MODEL NO. WILL CONTAIN A SUFFIX WHICH WILL PERTAIN TO THE NUMBER OF UNITS GANGED. 1 (−2, −3, ETC.)

MECHANICAL DATA

BASIC MODEL	CONNECTOR	DIMENSIONS A	DIMENSIONS B	DIMENSIONS C
STC2180A	TYPE C	.580 (1,473)	3.210 (8,153)	2.980 (7,569)
STH2180A	TYPE HN	.690 (1,752)	3.410 (8,661)	3.030 (7,696)
STM2180A	TYPE SMA	.400 (1,016)	2.840 (7,213)	2.750 (6,985)
STB2180A	TYPE BNC	.530 (1,346)	3.110 (7,899)	2.980 (7,569)
STT2180A	TYPE TNC			
STN2180A	TYPE N	.690 (1,752)	3.410 (8,661)	3.030 (7,696)

PHYSICAL CHARACTERISTICS

Minimum Life	100,000 operations
Weight with Type N connectors	3 oz. max.

MATERIALS & FINISHES

Bodies: Aluminum (Painted Sage Hammertone Green)
Coax Contacts: Beryllium Gold Plated
Connectors: Brass Chrome Plated

All Sageline Materials & Finishes to Government Specs.
Alternative Materials & Finishes on Special Order

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LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

APPLICATION NOTES ELECTROMECHANICAL COAXIAL SWITCHES

HOW TO AVOID "HUNTING" & "RUNAWAYS" AMONG INTERCONNECTED SWITCHES

Customers frequently wish to interconnect two or more rotor-type switches through a single control, or to control rotor-type switches from more than one location. When you attempt to operate two or more rotor-type switches together, the rotary solenoids are likely to interact. Presented here are some typical interaction problems and their solutions.

Two or more switches cannot be wired in series, because the first unit that "homes" will shut off the drive power. On the other hand, if the switches are wired with corresponding terminals in parallel and they happen to start out of phase or become out of phase, they may operate continuously ("runaways"). Figure 1 illustrates such a parallel interconnection, and shows how "hunting" can be caused by the common control line. Note that the common control line and its parallel interconnection of the two drive solenoids forms a path via which the solenoid that is still operating can feed power to the solenoid which has already reached its selected position.

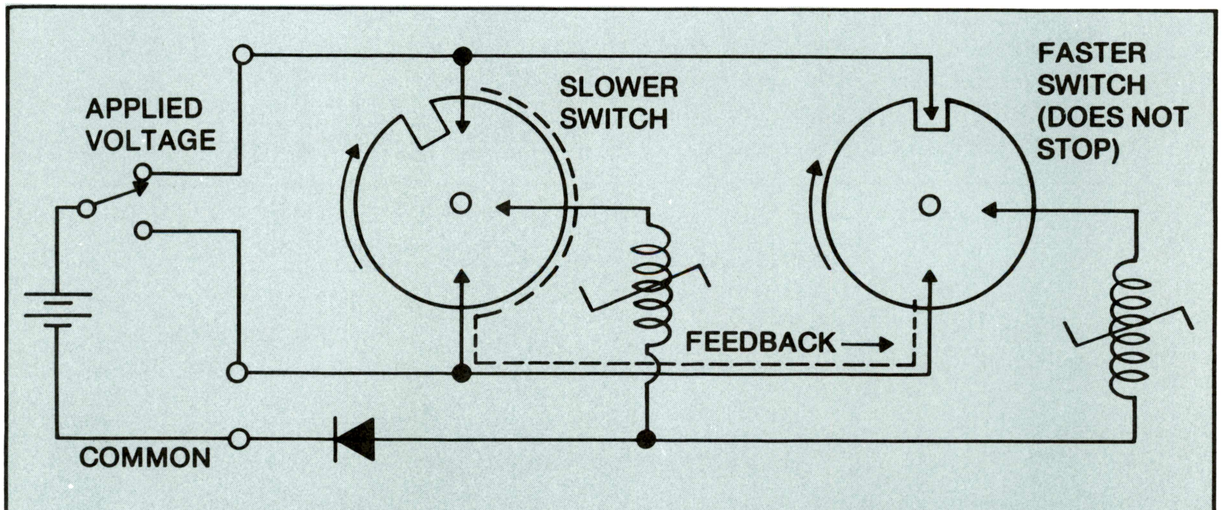

FIGURE 1: "HUNTING" CAUSED BY COMMON CONTROL LINE

APPLICATION NOTES - ELECTROMECHANICAL COAXIAL SWITCHES (Cont'd)

The potential for "hunting" and "runaways" shown in Figure 1 can be avioded by adding diodes to the control lines as shown in Figure 2. One diode is required for each control terminal; therefore, 2-6 position switches would require 12 diodes. The cost can be kept quite low by using diodes such as the 1N4004. (For purposes of simplicity and clarity, the RF circuits are not shown in Figures 2, 3 and 4.)

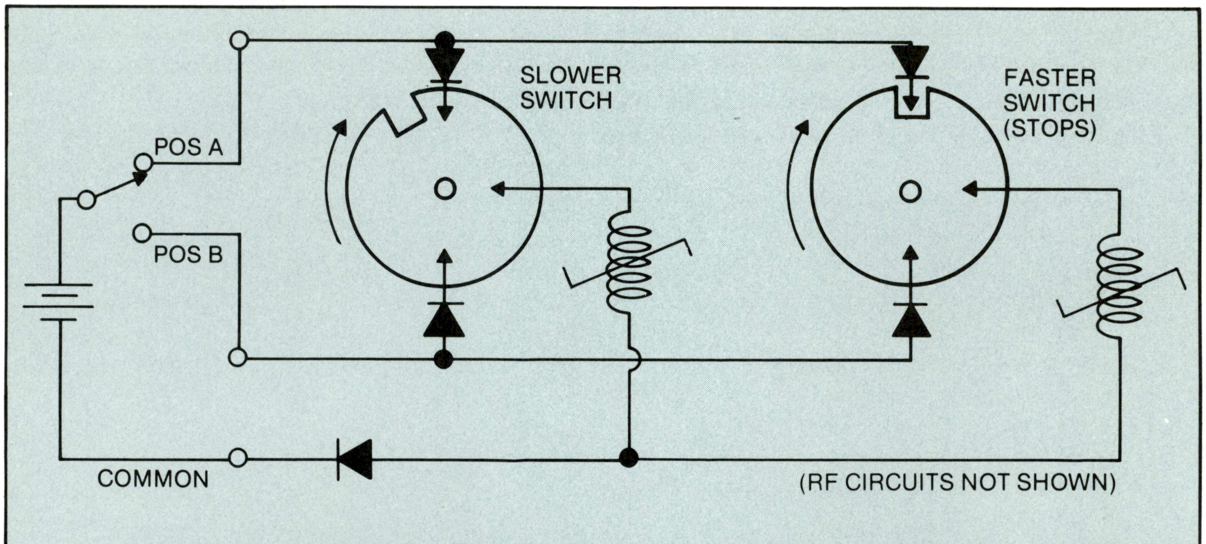
SLOWER SWITCH
FASTER SWITCH (STOPS)
POS A
POS B
COMMON
(RF CIRCUITS NOT SHOWN)

FIGURE 2: ELIMINATING "HUNTING" THROUGH USE OF ISOLATING DIODES

Another way to eliminate "hunting" is to use a separate pole on the local selector switch for each remote switch. Figure 3 illustrates this approach for the case of two 2-position remote switches. Inasmuch as this circuit does not require diodes, it can be used with AC-operated switches.

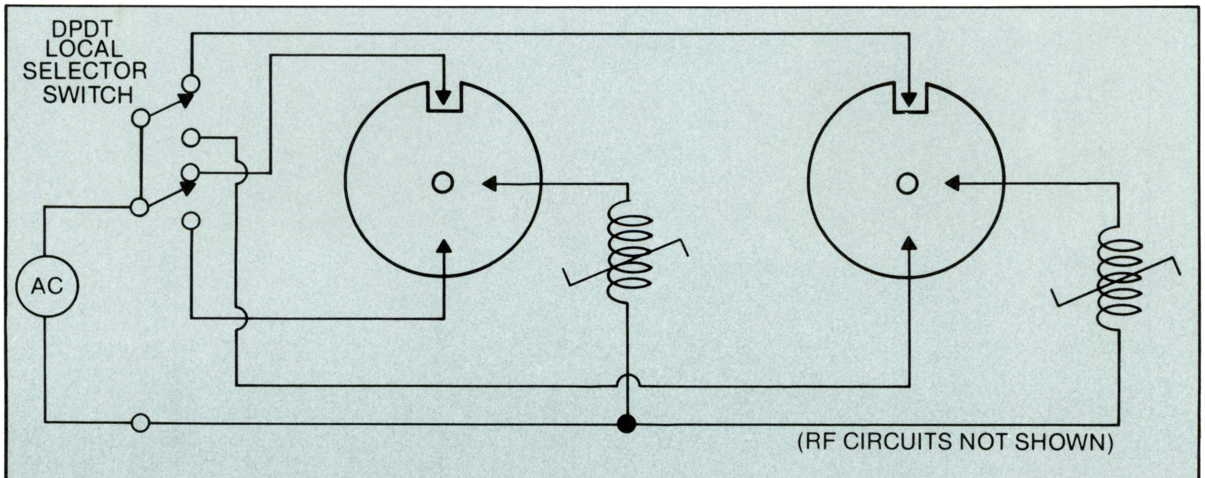
DPDT LOCAL SELECTOR SWITCH
AC
(RF CIRCUITS NOT SHOWN)

FIGURE 3: ELIMINATING "HUNTING" THROUGH USE OF MULTI-POLE LOCAL SELECTOR SWITCH

APPLICATION NOTES-ELECTROMECHANICAL COAXIAL SWITCHES (Cont'd)

The most economical solution to the hunting problem, when two remotely located switches are to be controlled together, is to order switches with indicator circuits. This is an additional wafer on the rotary solenoid shaft, and is normally used to show that the switch has actually reached its selected position. You can use the indicator circuit on the "master" switch to control the "slave" switch rotary solenoid. This will increase the actuation time, but it will eliminate the danger of hunting. The Sage indicator circuit is a factory option. Please note that it cannot be added to a switch in the field unless the extra wafer is already in place.

This "master-slave" circuit does not require diodes; therefore, it can be used with AC-operated switches.

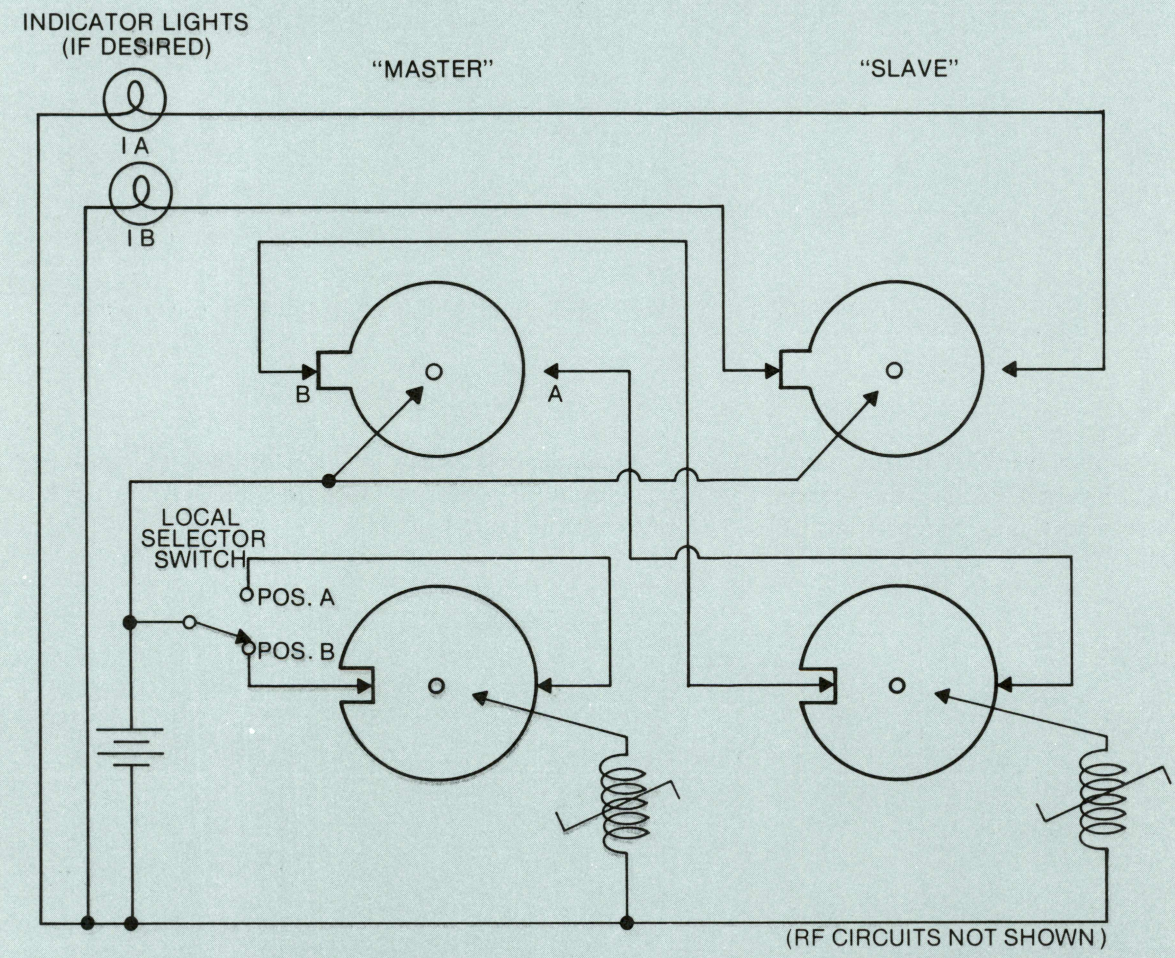

FIGURE 4: ELIMINATING "HUNTING" THROUGH USE OF "MASTER-SLAVE" OPERATION

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APPLICATION NOTES-ELECTROMECHANICAL COAXIAL SWITCHES (Cont'd)

INDICATOR CIRCUIT CONSIDERATIONS

The indicator circuit is a wafer switch that is driven by the same shaft as the RF coaxial switch. It should not be used by itself as a transmitter interlock (to turn off RF power during switching), because the indicator circuit closes slightly before the RF switch is in final position, and opens after the RF switch moves slightly away from true (on center) position. High power applied to the coaxial switch during this period could damage the RF contacts. The solution is to provide time delay circuits which de-energize the transmitter before the remote switch is energized, and which briefly delay turning on the transmitter after the indicator shows a completed circuit.

POWER SUPPLY CONSIDERATIONS

Rotor type switches draw their actuating power in a series of pulses. If you are using SCRs to energize the switch drive coils, you should be aware that there will be interruptions in the coil circuit before the switch contacts reach their final positions. These interruptions will tend to turn off your SCRs; therefore, it may not be feasible to use power supplies employing SCRs unless auxiliary logic is used.

Sage rotor type switches are manufactured with a combination of diodes and contact protectors wired internally. This means that they must be driven with voltage of a particular polarity.

If Radio Frequency Interference (RFI) is likely to be a problem, it is best to avoid noise from the solenoid contacts by installing low pass filters in all leads directly at the switches. There is no room inside the housings for such filters. In the case of a 28-volt switch, the control lead filters must be rated to handle 3 amperes, although the *average* drive current is typically less than 1 ampere.

Incoming inspection or testing of the switches should make use of power supplies having adequate peak current capability. (Some current-limiting devices may prevent proper pull-in of the switch solenoids.) One way to accomplish this is to add a large capacitor (e.g. 15,000 microfarad, 50 volts) across the power supply output terminals. This will supply the necessary surge current.

SWITCHING RATE (DUTY CYCLE)

The allowable switching rate or duty cycle is determined by the heating of the solenoid coil. The torque load determines the switching time, which in turn determines the on-time of the current in the coil. The more slowly a switch operates, the longer the current flows and the more the coil heats. As the coil heats, its resistance increases, and less current is drawn from the line. Lower current reduces the output torque and slows the switch action, which increases the coil current on-time. In this manner, coil heat can increase to the point where thermal damage or destruction can occur.

The duty cycle is determined by solenoid selection and torque loading. The recommended *maximum* cycling rate of rotary solenoids is 20 to 40 cycles per minute at room ambient temperature.

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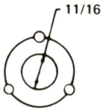
WIRING & INSTALLATION INSTRUCTIONS FOR RADIAL COAXIAL SWITCHES (SA & SF SERIES ONLY)

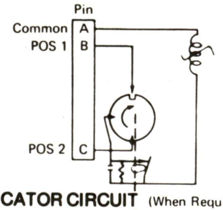
PANEL MOUNTING DETAIL


.187 dia through 3 holes equally spaced on a 1.312 dia B.C.
11/16 through
Clearance for 8-32 screw 1/4" long (plus panel thickness)

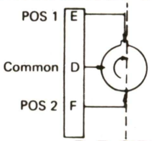
NOTE: Standard DC units are polarized to have negative (—) Common Pin A. Positive (+) Common Pin A units are available on request.

Remote Series SA 2180
Types E, F, G, H,
EL, FL, GL, and HL

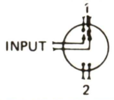
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C

INDICATOR CIRCUIT (When Required)


POS 1 E
Common D
POS 2 F

R. F. CIRCUIT

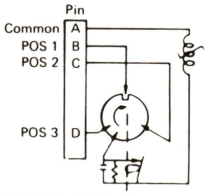


MATING POWER PLUGS

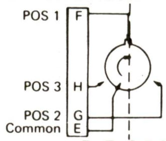
MS 3106 - 10SL - 3S W/O Lgt Ckt
MS 3106 - 14S - 6S with Lgt Ckt

Remote Series SA 3120
Types E, F, G, H,
EL, FL, GL, and HL

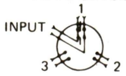
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C
POS 3 D

INDICATOR CIRCUIT (When Required)


POS 1 F
POS 3 H
POS 2 G
Common E

R. F. CIRCUIT

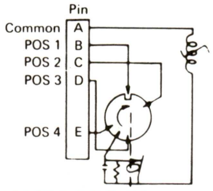


MATING POWER PLUGS

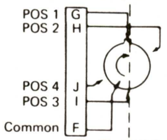
MS 3106 - 14S - 2S W/O Lgt Ckt
MS 3106 - 18 - 8S with Lgt Ckt

Remote Series SA 460 120
Types E, F, G, H,
EL, FL, GL, and HL

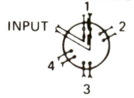
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C
POS 3 D
POS 4 E

INDICATOR CIRCUIT (When Required)


POS 1 G
POS 2 H
POS 4 J
POS 3 I
Common F

R. F. CIRCUIT

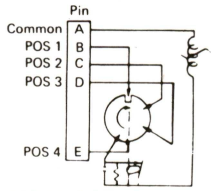


MATING POWER PLUGS

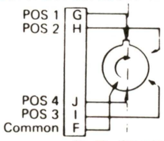
MS 3106 - 14S - 5S W/O Lgt Ckt
MS 3106 - 18 - 1S with Lgt Ckt

Remote Series SA 460
Types E, F, G, H,
EL, FL, GL, and HL

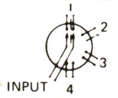
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C
POS 3 D
POS 4 E

INDICATOR CIRCUIT (When Required)


POS 1 G
POS 2 H
POS 4 J
POS 3 I
Common F

R. F. CIRCUIT

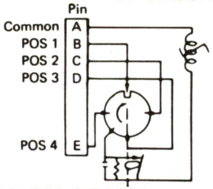


MATING POWER PLUGS

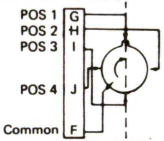
MS 3106 - 14S - 5S W/O Lgt Ckt
MS 3106 - 18 - 1S with Lgt Ckt

Remote Series SA 490
Types E, F, G, H,
EL, FL, GL, and HL

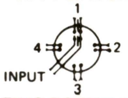
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C
POS 3 D
POS 4 E

INDICATOR CIRCUIT (When Required)


POS 1 G
POS 2 H
POS 3 I
POS 4 J
Common F

R. F. CIRCUIT

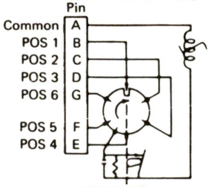


MATING POWER PLUGS

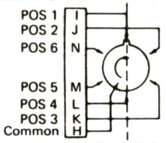
MS 3106 - 14S - 5S W/O Lgt Ckt
MS 3106 - 18 - 1S with Lgt Ckt

Remote Series SA 660
Types E, F, G, H,
EL, FL, GL, and HL

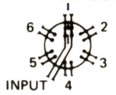
ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C
POS 3 D
POS 6 G
POS 5 F
POS 4 E

INDICATOR CIRCUIT (When Required)


POS 1 I
POS 2 J
POS 6 N
POS 5 M
POS 4 L
POS 3 K
Common H

R. F. CIRCUIT

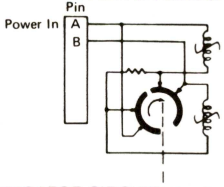

6
2
5
3
INPUT
4

MATING POWER PLUGS

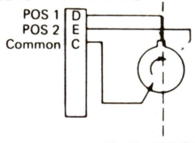
MS 3106 - 16S - 1S W/O Lgt Ckt
MS 3106 - 20 - 27S with Lgt Ckt

Remote Series SA 260 (SR)
Types E, F, G, H,
EL, FL, GL, and HL

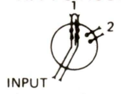
SPRING RETURN ACTUATOR CIRCUIT


Pin
Power In A
B

INDICATOR CIRCUIT (When Required)


POS 1 D
POS 2 E
Common C

R. F. CIRCUIT

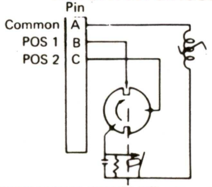


MATING POWER PLUGS

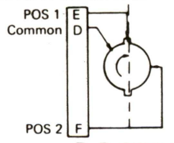
MS 3106 - 10SL - 4S W/O Lgt Ckt
MS 3106 - 14S - 5S with Lgt Ckt

Remote Series SF 490
Types EL, FL, GL, and HL

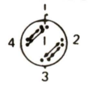
TRANSFER ACTUATOR CIRCUIT


Pin
Common A
POS 1 B
POS 2 C

INDICATOR CIRCUIT (When Required)


POS 1 E
Common D
POS 2 F

R. F. CIRCUIT



MATING POWER PLUGS

MS 3106 - 10SL - 3S W/O Lgt Ckt
MS 3106 - 14S - 6S with Lgt Ckt

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VHF & UHF AMPLIFIERS & PRE-AMPLIFIERS

(EASILY REPAIRED DISCRETE COMPONENT CONSTRUCTION)

CONTENTS OF THIS SECTION **PAGE**

A Guide to Amplifier Selection **65-66**
Custom Engineering Capabilities **67-73**
Standard Products **74-79**
Application Notes **80**

A GUIDE TO AMPLIFIER SELECTION

The amplifiers listed in the standard product tables are categorized in two groups.

- *The 3-stage designs* have been carried over from our previous catalog in response to customer interest. These are excellent low-noise high-gain IF pre-amplifiers for laboratory use. They are rated for 28-volt operation, but noise figure and gain are usually adequate above 18 volts. Output impedance is not specified for these models, but because of their relatively high gain, they can be followed with a pad to obtain a predictable output resistance. (Example: Model A30-50-50)
- *The 2-stage amplifiers* listed in the standard product tables are new designs which we have developed since our last catalog was published. These have been optimized for broad bandwidth, low output VSWR (without which broad bandwidth specifications are meaningless), low third-order intermodulation or fast recovery (as needed for close-in radar or NMR work). Examples of the latter are Model A70-19-30 (low intermodulation) and Model A15-60-1C-3 (fast recovery). Required power and noise figure increase when intermodulation or intercept point is specified, but the trade-offs can be tailored to any specific application. (For most applications, mixer intermodulation is the limiting factor.) The major attributes of the 2-stage designs are as follows.

(1) designed for 15VDC operation ... will operate to 12.6VDC with reasonable performance
(2) generally broad bandwidth ... several designs have octave bandwidths
(3) good S21•S12 products
(4) low output VSWR (a specified parameter)
(5) moderate gain

Some of the amplifiers listed are suitable for operation over very wide temperature ranges. (Heatsinking must be provided for the high temperature end of the range.) All amplifiers degrade in performance at high temperatures, but usually much less than is observed in diode mixers. For critical requirements, each amplifier must be tested over the specified temperature range (which, of course, means extra time and money)

VHF & UHF AMPLIFIERS & PRE-AMPLIFIERS (Continued)

because the semiconductors are not screened for high temperature VHF gain by the manufacturers. A given amplifier without the temperature test specification will be less expensive than the same model with full temperature testing.

A parameter which is generally ignored, or at least omitted from specifications, is the product of forward gain (S21) and reverse transfer (S12). For a 6-dB pad, this product is −12 dB. For one typical competitive modular amplifier, the gain is 15 dB and the S21•S12 product is only −6 dB. For the Sage Model A-70-19-30, on the other hand, the S21•S12 product is −20 dB or better (19 dB forward gain, 45 dB isolation). A low S21•S12 product (high negative number) is mandatory if VSWR is important and the source and load are not well matched. For example, adding a narrowband filter to the output of the Sage amplifier will not destroy the input match.

You may wonder why we use discrete construction. For one thing, it makes custom designs highly practical. For another, it enables you to make field repairs. (Alternatively, you can return the amplifiers to us, and we will repair them to the original specifications). Also, with discrete construction, there is the possibility of changing the performance without modifying the external dimensions, and there is some extra flexibility in the voltage and current requirements.

We should be happy to discuss any special needs which are not met by our standard amplifiers, and to submit our quotation for special designs. The following section presents selected examples of our custom engineering capabilities in amplifiers and mixer-amplifiers. If you need additional information, or wish to discuss a special requirement, please feel free to call. Our engineering staff is available to you at all times.

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CUSTOM ENGINEERING CAPABILITIES IN VHF/UHF AMPLIFIERS, PRE-AMPLIFIERS, & MIXER-AMPLIFIER COMBINATIONS

MODIFICATIONS OF STANDARD AMPLIFIER DESIGNS

Our engineers are available to discuss and quote on your special requirements. Many such needs can be met through modifications of our standard designs. Examples of such modifications are listed below.

- amplifiers for operation with special power supplies (e.g., reversed or split polarity - negative ground is standard)
- units for operation from unregulated DC or AC
- units for operation from DC supplied through the output coaxial cable
- amplifiers with filtering built in, either inside or alongside, including the combination of a three-pole filter and an isolating amplifier (nominally unity gain) - these designs typically use feedback amplifiers with separate passive filters.

Impedances

The amplifiers listed in the tables are designed for operation with 50-ohm sources and loads. For some of these models, it is a simple matter to adapt the amplifiers to different source impedances (e.g. 100 ohms from a single-balanced 2-diode mixer) or to modify them for 75-ohm or 93-ohm output impedances. Sometimes other parameters will change. For example, the input stage will operate at lower current for optimum noise figure from a 100-ohm source, so the overload point and gain may differ from the 50-ohm version. Model A70-19-30 becomes an A70-19-40-s in the 75-ohm version because the output power is slightly higher. The degree of difficulty may vary somewhat, but we can supply 75-ohm versions of any of the models listed if you so request.

Preferred Voltages

All our 28-volt amplifiers operate well at 18 volts. For voltages higher than 28, we prefer to add an external voltage-dropping resistor and a zener diode, rather than adding components inside to handle the extra power; however, we can supply units either way. All 15-volt amplifiers will operate satisfactorily on 12 volts, with some loss of power. We can also optimize them for 12-volt operation, and we can supply them with 78M15 regulators so that they will operate with voltages ranging from 17.5 to 30 volts, or possibly, from 14.5 to 30 volts. (The extra power dropped by the regulator will have to be dissipated somehow.)

If you wish to operate from a negative (−) 24 or 48 volts, the problems become more difficult, and may require some change in specifications. Nevertheless, once the nonrecurring engineering is paid for, you should find the special amplifier to be more satisfactory than attempting to use a DC-DC power supply.

Whether you are considering modifications to a standard amplifier or a custom design tailored to your needs, get one of our engineers on the phone and discuss the matter. Early design discussions invariably save you time and money.

CUSTOM ENGINEERING CAPABILITIES IN VHF/UHF AMPLIFIERS, PRE-AMPLIFIERS, & MIXER-AMPLIFIER COMBINATIONS (Continued)

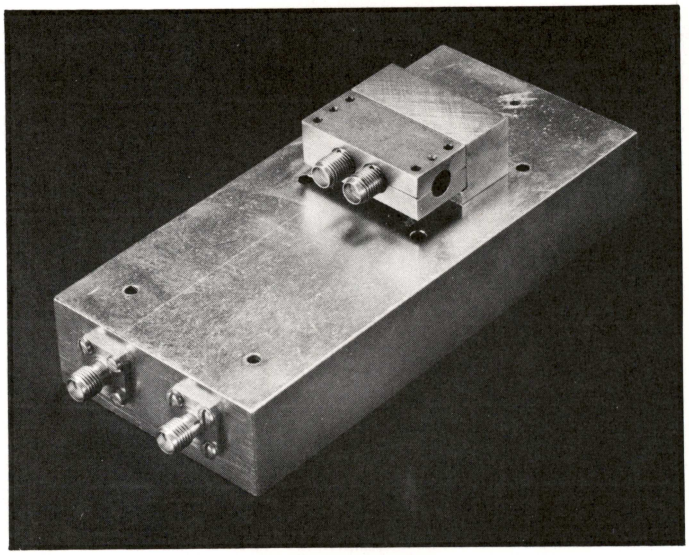
Filter-Buffer Units

If a restricted bandpass is important to your application, you can add an external filter-buffer unit consisting of a 3-pole filter and an isolating output amplifier. Such a unit is the Sage BF design. The gain is less than 6 dB. The input is fed from the pre-amplifier, and the output has low VSWR over a wide band, with more than 30 dB of back-isolation. To request a quotation on such a unit, please specify center frequency and bandwidth at 3-dB down. Standard designs are 10% and 20% bandwidth, with center frequencies of 30, 60, and 70 MHz. (Example: Model BF-70-7 ... 70 MHz center frequency and 10% bandwidth at 3-dB points) The output at the 1-dB compression point is +13 dBm minimum. Standard impedance is 50 ohms. Supply voltage can be +12VDC, +15VDC, or +28VDC. (If not specified, we will match it to your amplifier supply voltage.)

The BF design series described in the preceding paragraph offers a fairly low cost means for you to add filtering to your amplifiers. We are not, of course, limited to the standard BF designs. We can supply filter-buffer units which ensure that output impedance is a broadband match at frequencies ranging from 10 to 100 MHz. The output compression point of such units is about +15 dBm, with the input fed from a pad or good match. If more complicated filtering is required, we can supply a pair of amplifiers (with good S21•S12 products) which will be compatible with a bandpass filter placed between them (50 ohms in and out). We can supply the filter, or we can match the amplifiers to another vendor's filter supplied by you or procured by us for you.

CUSTOM ENGINEERING CAPABILITIES IN VHF/UHF AMPLIFIERS, PRE-AMPLIFIERS, & MIXER-AMPLIFIER COMBINATIONS (Continued)

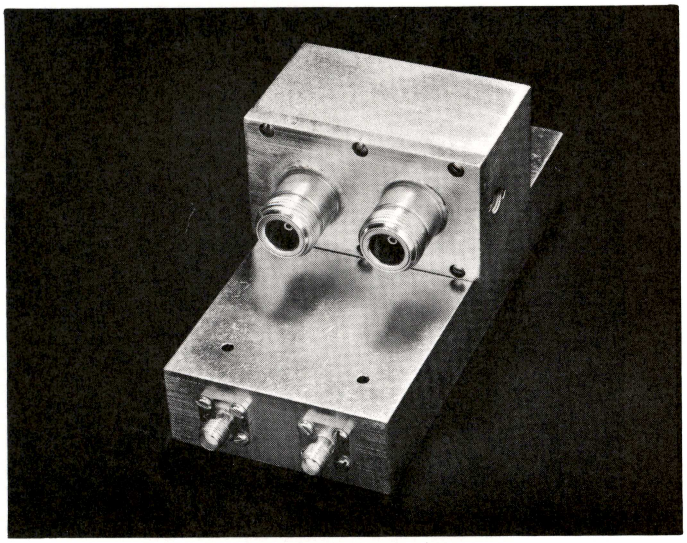
COMMUNICATIONS BAND MIXER-PREAMPLIFIERS FEATURE DUAL CHANNEL IFs



For five different communications bands in L and X-band, Sage developed mixer-preamplifiers for 70 MHz IF operation. The units in this series use the form factors shown in the photographs. All feature IF monitor outputs having the same gain as the IF outputs, thereby providing dual channel operation. Isolation between IF and IF monitor outputs is 20 dB minimum. The performance characteristics of five such mixer-preamplifiers are shown in the following columns.

(ALL UNITS LISTED HAVE 70 MHz IFs)

MODEL NUMBER	SIGNAL FREQUENCY (GHz)	MAXIMUM VSWR	MINIMUM LO/RF ISOLATION	MAXIMUM NOISE FIGURE
FMA-2173	.755-.985	1.7	6 dB	7.5 dB
FMA-1469-1	1.7-2.4	1.7	6 dB	7.5 dB
FMA-1710	2.4-2.7	1.7	6 dB	8.5 dB
FMA-1649	4.4-5.0	1.7	6 dB	8.5 dB
FMA-1469-2	7.7-8.4	1.5	6 dB	8.5 dB

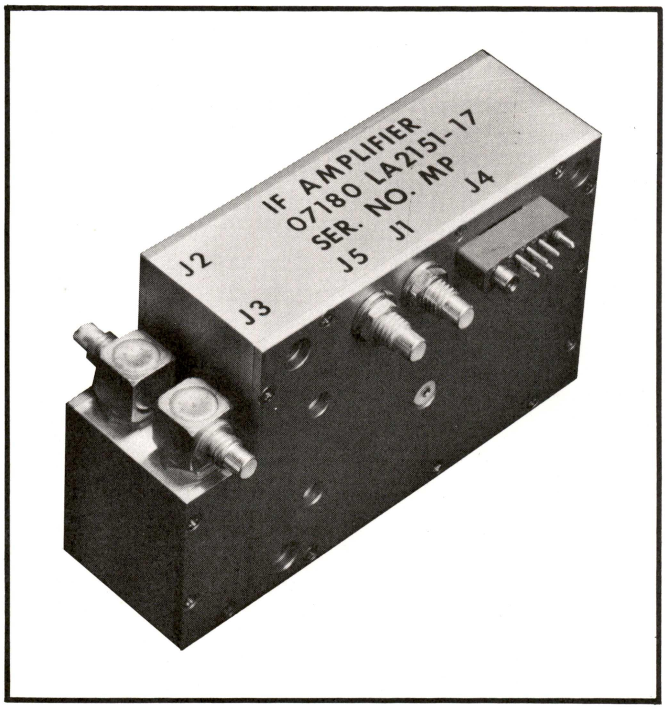


All mixer-preamplifiers in this design series provide monitoring of mixer diode current. The mixer diodes are field-replaceable.

CUSTOM ENGINEERING CAPABILITIES IN VHF/UHF AMPLIFIERS, PRE-AMPLIFIERS, & MIXER-AMPLIFIER COMBINATIONS (Continued)

LINEAR AGC 150-MHz NARROWBAND AMPLIFIER FOR MILITARY AIRCRAFT & MICROWAVE LANDING SYSTEMS

Sage Model LA2151-17 linear AGC 150-MHz narrowband amplifier has been supplied to several customers in this country and abroad for use in microwave landing systems for military aircraft. The unit provides a linear 65-dB minimum AGC range. A video detector and amplifier provide a sample of the IF signal, and an auxiliary input permits injection of an IF signal for "built-in-test." The DC power requirement of the units is extremely low (typically 60 mA at 20 VDC).

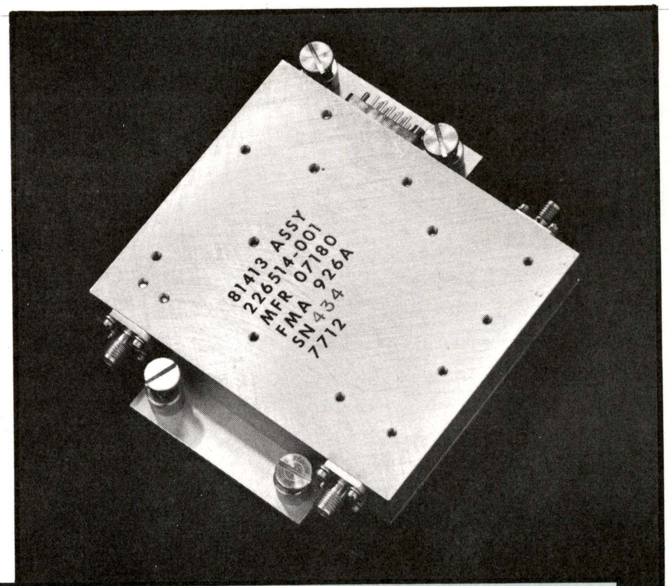


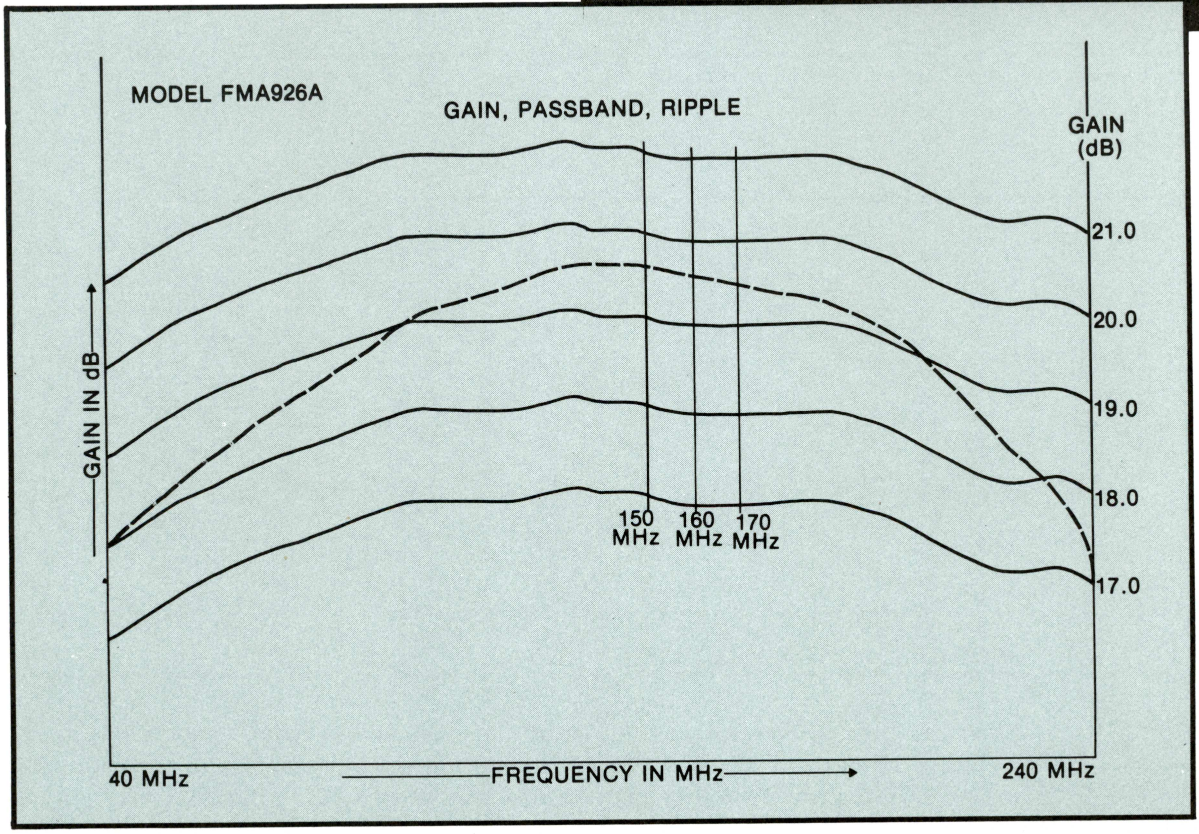
Model Number		LA2151-17
Center Frequency		150 MHz ±1 MHz
3-dB Bandwidth @ 0V AGC		14 MHz typical
3-dB Bandwidth @ 3V AGC		10 MHz typical
Pulse Sensitivity		(2Vpeak pulse for an input of −87 dBm typical)
Skirt Response	Attenuation @ 102 MHz	55 dB minimum
	Attenuation @ 126 MHz	30 dB minimum
	Attenuation @ 174 MHz	30 dB minimum
	Attenuation @ 198 MHz	55 dB minimum
AGC Range		65 dB minimum
Pulse Response	Maximum Rise Time	0.2 microsecond

CUSTOM ENGINEERING CAPABILITIES IN VHF/UHF AMPLIFIERS, PRE-AMPLIFIERS, & MIXER-AMPLIFIER COMBINATIONS (Continued)

WIDEBAND MIXER-PREAMPLIFIER FOR AIRBORNE ECM SYSTEM

Sage Model FMA926A includes a PIN diode limiter and a video detector at the RF input. LO-to-RF isolation is 30 dB typical, and LO and RF VSWR are typically less than 1.5. An LO level of +9 dBm to +15 dBm ensures good intermodulation characteristics. The overall noise figure of the unit is less than 11 dB. RF-to-IF gain is approximately 12 dB. The pre-amplifier has less than 3 dB ripple from 40-240 MHz, and its noise figure is typically 1.6 dB. The gain-ripple test data for a typical unit are illustrated below.

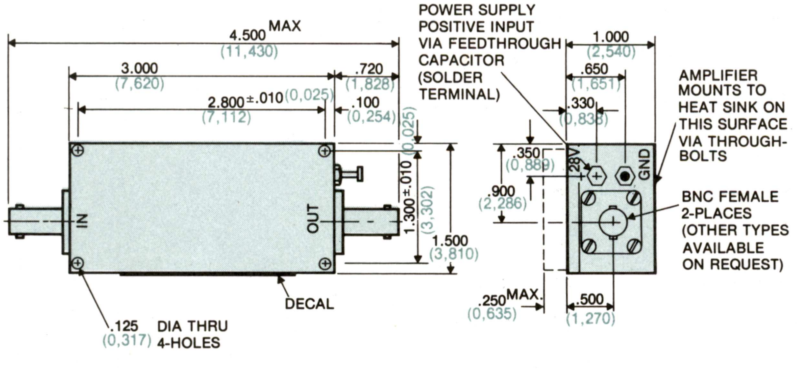




SPECIAL PURPOSE VHF/UHF AMPLIFIERS & PRE-AMPLIFIERS (A SELECTION OF CUSTOM-ENGINEERED DESIGNS, MANY OF WHICH WERE PRODUCED IN QUANTITY)

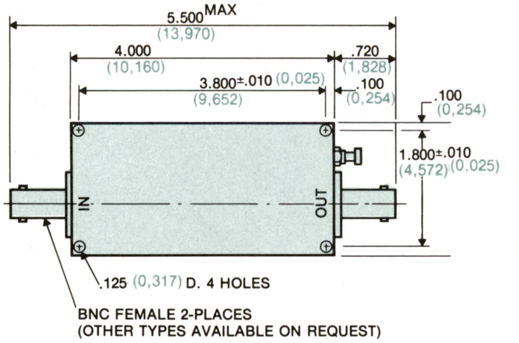
MODEL NUMBER	ORIGINAL APPLICATION	CENTER FREQUENCY (MHz)	3-dB BANDWIDTH (MHz)	MAXIMUM NOISE FIGURE (dB)	MINIMUM GAIN (dB)
A-15-60-1C-3	fast recovery unit for close-in radar & NMR work	15	6	1.5	56
A-30-26-5	pre-amplifier with customer-specified lower gain	30	6	1.5	25
A-45-32-1C-3 A-45-48-2C	post-amplifier application never disclosed	45 45	25 20	1.6 1.5	30 48
A-70-8-1C	amplifier portion of amplifier/up-converter	70	20	5.0	8
A-70-26-5	pre-amplifier	70	10	1.5	23
A-70-45-1C-3	IF amplifier for microwave link	70	10 @ 1-dB	1.6	45
A-70-50-1C-1	application never disclosed	70	10	1.6	47
A-70-52-1C-3	IF amplifier for microwave link	70	10 @ ±0.5 dB	1.6	52-57
A-70-34-40	used in mixer-preamplifier assembly	70	20	1.7	33
A-90-26-5	special low noise preamplifier	90	10	1.6	23
A-150-18-10	used in mixer-preamplifier assembly	150	180	2.0 @ 150	18
A-200-18-10	used in mixer-preamplifier assembly	200	100	3.0	17
A-700-18-10	used in mixer-preamplifier assembly	700	150	4.0	16
A-1300-15-5	special low noise pre-amplifier	1300	200	3.0	14

•Gain is measured in a 50-ohm system, but the units operate well at higher source impedances.


4.500 MAX
(11,430)
3.000
(7,620)
.720
(1,828)
2.800±.010(0,025)
(7,112)
.100
(0,254)
IN
OUT
1.300±.010 (0,025)
(3,302)
1.500
(3,810)
DECAL
.125 DIA THRU
(0,317) 4-HOLES
POWER SUPPLY
POSITIVE INPUT
VIA FEEDTHROUGH
CAPACITOR
(SOLDER
TERMINAL)
1.000
(2,540)
.650
(1,651)
.330
(0,838)
.350
(0,889)
.900
(2,286)
28V
GND
.250 MAX.
(0,635)
.500
(1,270)
AMPLIFIER
MOUNTS TO
HEAT SINK ON
THIS SURFACE
VIA THROUGH-
BOLTS
BNC FEMALE
2-PLACES
(OTHER TYPES
AVAILABLE
ON REQUEST)

MATERIAL IS IRRIDITED ALUMINUM

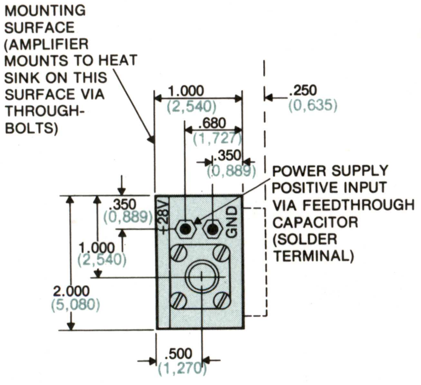
PACKAGE CONFIGURATION J


5.500 MAX
(13,970)
4.000
(10,160)
.720
(1,828)
3.800±.010 (0,025)
(9,652)
.100
(0,254)
.100
(0,254)
1.800±.010
(4,572)(0,025)
IN
OUT
.125 (0,317) D. 4 HOLES
BNC FEMALE 2-PLACES
(OTHER TYPES AVAILABLE ON REQUEST)

PACKAGE

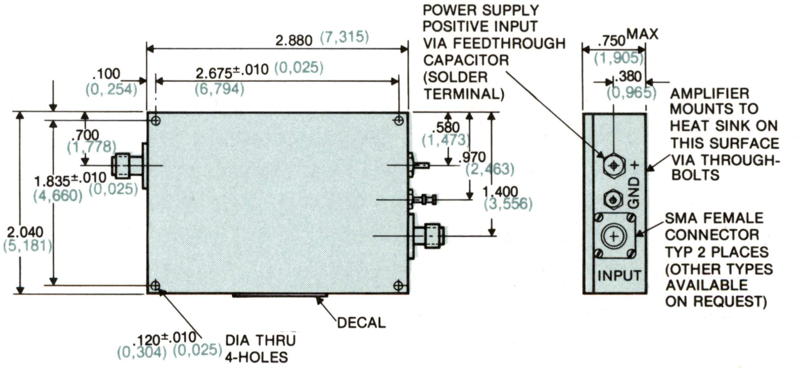
NOTES The amplifiers listed above are presented in part to demonstrate our custom engineering capabilities, and also to give you a selection of special designs from which you may be able to draw for your own needs. The engineering has been done and paid for, so if you see anything here that even comes close to meeting your needs, please ask us for a quotation. You may be able to save considerable money

MINIMUM OUTPUT AT 1-dB COMPRESSION (mW)	PACKAGE CONFIGURATION (SEE DRAWING)	SOURCE IMPEDANCE (OHMS)	MAXIMUM INPUT VSWR (50-OHM REF)	POWER SUPPLY VOLTAGE	MODEL NUMBER
100	K	50	1.5	+28VDC	A-15-60-1C-3
5	J	50	No Spec	+28VDC	A-30-26-5
100	J	50	1.5	+28VDC	A-45-32-1C-3
200	J	50	3.0	+28VDC	A-45-48-2C
100	Special	50/75 (specify)	1.5	+15VDC	A-70-8-1C
10	J	50	No Spec	+28VDC	A-70-26-5
100	J	50	1.5	+28VDC	A-70-45-1C-3
100	J	50	1.5	+28VDC	A-70-50-1C-1
100	J	50	1.5	+28VDC	A-70-52-1C-3
40	Special	50/100*	No Spec	+28VDC	A-70-34-40
5	J	50	No Spec	+28VDC	A-90-26-5
10	X	50/100*	3.0	+15VDC	A-150-18-10
10	Special	50/100*	3.0	+15VDC	A-200-18-10
10	Special	50/100*	No Spec	+15VDC	A-700-18-10
5	J	50	No Spec	+15VDC	A-1300-15-5


MOUNTING SURFACE (AMPLIFIER MOUNTS TO HEAT SINK ON THIS SURFACE VIA THROUGH-BOLTS)
1.000 (2,540)
.680 (1,727)
.350 (0,889)
.250 (0,635)
POWER SUPPLY POSITIVE INPUT VIA FEEDTHROUGH CAPACITOR (SOLDER TERMINAL)
+28V
GND
.350 (0,889)
1.000 (2,540)
2.000 (5,080)
.500 (1,270)

MATERIAL IS IRRIDITED ALUMINUM

CONFIGURATION K


2.880 (7,315)
.100 (0,.254)
2.675±.010 (0,025) (6,794)
POWER SUPPLY POSITIVE INPUT VIA FEEDTHROUGH CAPACITOR (SOLDER TERMINAL)
.750 MAX (1,905)
.380 (0,965)
AMPLIFIER MOUNTS TO HEAT SINK ON THIS SURFACE VIA THROUGH-BOLTS
.700 (1,778)
1.835±.010 (4,660) (0,025)
2.040 (5,181)
.580 (1,473)
.970 (2,463)
1.400 (3,556)
+
GND
SMA FEMALE CONNECTOR TYP 2 PLACES (OTHER TYPES AVAILABLE ON REQUEST)
INPUT
DECAL
.120±.010 (0,304) (0,025) DIA THRU 4-HOLES

MATERIAL IS IRRIDITED ALUMINUM

PACKAGE CONFIGURATION X

as opposed to having a unit designed from scratch. Get one of our engineers on the phone, and tell him what you need. There may well be other designs which can be modified to meet your requirements. The above listing is merely partial.

3-STAGE VHF/UHF AMPLIFIERS & PRE-AMPLIFIERS - STANDARD PRODUCT DATA

MODEL NUMBER	CENTER FREQUENCY (MHz)	3-dB BANDWIDTH (MHz)	MAXIMUM NOISE FIGURE (dB)	MINIMUM GAIN (dB)	MINIMUM OUTPUT AT 1-dB COMPRESSION (mW)
A-30-50-50	30	10	1.5	50	50
A-30-50-50-1	30	10	1.5	50	50
A-30-50-50-2	30	10	1.2	50	50
A-30-50-50-3	30	10	1.5	47	50
A-30-50-1C-3 #	30	10	1.6	47	100
A-30-50-2C #	30	10	1.5	50	200
A-30-50-2C-1 #	30	10	1.5	50	200
A-30-50-2C-2 #	30	10	1.2	50	200
A-45-50-50	45	10	1.5	50	50
A-45-50-50-1	45	10	1.5	50	50
A-45-50-50-2	45	10	1.3	50	50
A-45-50-1C #	45	10	1.5	50	100
A-45-50-1C-1 #	45	10	1.6	50	100
A-45-50-1C-2 #	45	10	1.3	50	100
A-60-50-50	60	10	1.6	47	50
A-60-50-50-1	60	10	1.6	47	50
A-60-50-50-2	60	10	1.3	47	50
A-60-50-50-3	60	10	1.6	47	50
A-60-48-1C #	60	20	1.6	45	100
A-60-48-1C-3 #	60	20	1.6	45	100
A-70-50-50	70	10	1.6	47	50
A-70-50-50-1	70	10	1.6	47	50
A-70-45-50-1	70	10	1.6	45	50
A-70-50-1C-3 #	70	10	1.6	46	100

#The -1C and -2C versions may require heat-sinking.

*Gain is measured in a 50-ohm system, but the units operate well at higher source impedances.

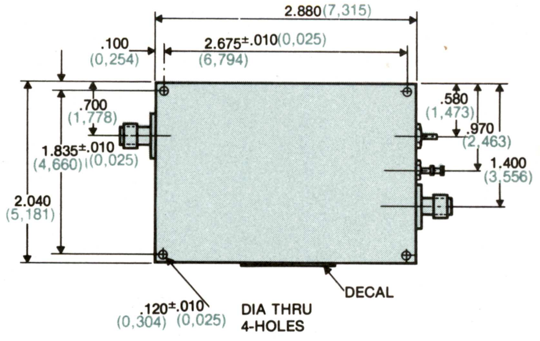
NOTES The models listed above are 3-stage amplifiers originally introduced as low noise pre-amplifiers. Noise figures are excellent, and the units have proven reliable in general laboratory use. The specified passbands are minimum; any restriction of same must be done with filters which are external to the amplifiers.

EXPLANATION OF MODEL NUMBERING CODE

A (Amplifier) - {center frequency} - {nominal gain} - {minimum output, mW, @ 1 dB compression}

EXAMPLE: Model A-30-50-50 signifies a unit tested at 30 MHz and having a nominal gain of 50 dB and a minimum output power of 50 milliwatts at 1-dB gain compression. A -1, -2, or -3 suffix added to a model number denotes an optimized unit, as explained below.

-1 ... input matched to 50 ohms
-2 ... noise figure optimized for 50-ohm source
-3 ... input & output matched to 50 ohms



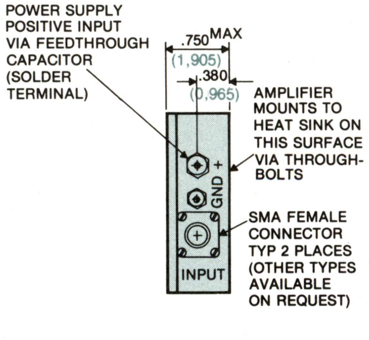
MATERIAL IS IRRIDITED ALUMINUM

PACKAGE

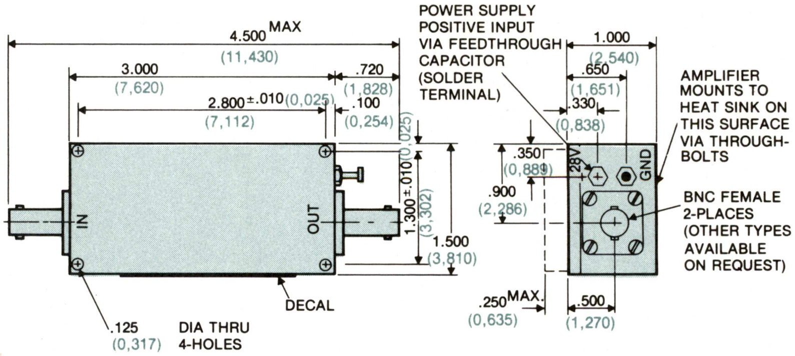
The below specifications apply at 25°C with +28VDC, 100 mA supplies. All units are operable from −40°C to +60°C, & with supply voltage as low as 18 volts. Noise figure is measured at center frequency with a 50-ohm source.

PACKAGE CONFIGURATION (SEE DRAWING)	SOURCE IMPEDANCE (OHMS)	MAXIMUM INPUT VSWR (50-OHM REF.)	MAXIMUM OUTPUT VSWR (50-OHM REF.)	MODEL NUMBER
J	50/100*	3.0	No Spec**	A-30-50-50
J	50	1.5	No Spec**	A-30-50-50-1
J	50	No Spec	No Spec**	A-30-50-50-2
J	50	1.5	1.5	A-30-50-50-3
J	50	1.5	1.5	A-30-50-1C-3
J	50/100*	No Spec	No Spec**	A-30-50-2C
J	50	1.5	No Spec**	A-30-50-2C-1
J	50	No Spec	No Spec**	A-30-50-2C-2
J	50	3.0	No Spec**	A-45-50-50
J	50	1.5	No Spec**	A-45-50-50-1
J	50	No Spec	No Spec**	A-45-50-50-2
J	50	3.0	No Spec**	A-45-50-1C
J	50	3.0	No Spec**	A-45-50-1C-1
J	50	No Spec	No Spec**	A-45-50-1C-2
J	50/75/100*	No Spec	No Spec**	A-60-50-50
J	50	1.5	No Spec**	A-60-50-50-1
J	50	No Spec	No Spec**	A-60-50-50-2
J	50	1.5	2.0	A-60-50-50-3
J	50	3.0	1.5	A-60-48-1C
J	50	1.5	2.0	A-60-48-1C-3
J	50/100*	No Spec	No Spec**	A-70-50-50
J	50	1.5	No Spec**	A-70-50-50-1
J	50	1.5	No Spec**	A-70-45-50-1
J	50	1.5	1.5	A-70-50-1C-3

**The output gives the specified performance into a 50-ohm resistive load.


POWER SUPPLY POSITIVE INPUT VIA FEEDTHROUGH CAPACITOR (SOLDER TERMINAL)
.750 MAX
(1,905)
.380
(0,965)
AMPLIFIER MOUNTS TO HEAT SINK ON THIS SURFACE VIA THROUGH-BOLTS
+
GND
SMA FEMALE CONNECTOR TYP 2 PLACES (OTHER TYPES AVAILABLE ON REQUEST)
INPUT

CONFIGURATION X


4.500 MAX
(11,430)
3.000
(7,620)
.720
(1,828)
2.800±.010(0,025)
(7,112)
.100
(0,254)
POWER SUPPLY POSITIVE INPUT VIA FEEDTHROUGH CAPACITOR (SOLDER TERMINAL)
1.000
(2,540)
.650
(1,651)
.330
(0,838)
AMPLIFIER MOUNTS TO HEAT SINK ON THIS SURFACE VIA THROUGH-BOLTS
IN
OUT
1.300±.010(0,025)
(3,302)
1.500
(3,810)
.350
(0,889)
.900
(2,286)
28V
GND
BNC FEMALE 2-PLACES (OTHER TYPES AVAILABLE ON REQUEST)
DECAL
.125
(0,317)
DIA THRU 4-HOLES
.250 MAX.
(0,635)
.500
(1,270)

MATERIAL IS IRRIDITED ALUMINUM

PACKAGE CONFIGURATION J

2-STAGE VHF/UHF AMPLIFIERS & PRE-AMPLIFIERS - STANDARD PRODUCT DATA

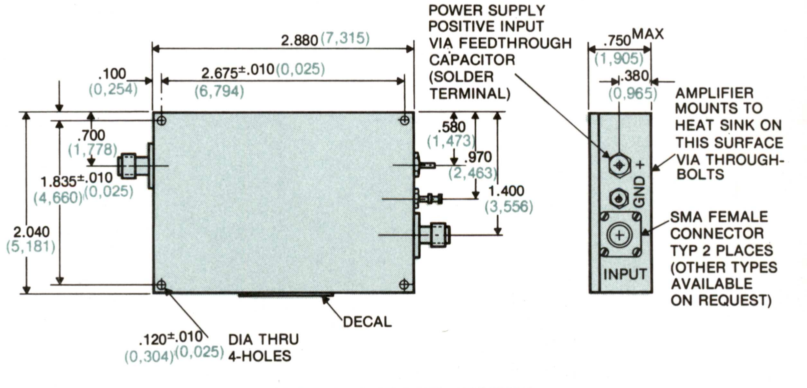
MODEL NUMBER	CENTER FREQUENCY (MHz)	3-dB BANDWIDTH (MHz)	MAXIMUM NOISE FIGURE (dB)	MINIMUM GAIN (dB)	MINIMUM OUTPUT AT 1-dB COMPRESSION (mW)
A-15-19-30	15	> 15	2	18	30
OA-15-19-25	15	20 @ 1dB	2	18	25
A-30-19-30	30	> 30	2	18	30
OA-30-19-30	30	20 @ 1 dB	2	18	30
A-30-24-30	30	> 30	2	23	30
A-45-15-30	45	> 45	3	13.5	30
OA-45-15-25	45	32 @ 1 dB	3	13.5	25
A-45-19-30	45	> 45	2	18	30
A-60-19-30	60	> 60	2	18	30
OA-60-19-25	60	42 @ 1 dB	2	18	25
A-70-15-50	70	> 50	4	13.5	50
A-70-19-30	70	> 50	2	18	30
A-120-19-30	120	180	2	19	30
A-150-19-30	150	180	2	19	30

*Gain is measured in a 50-ohm system, but the units operate well at higher source impedances.

Above specifications apply at 25°C with +15VDC, 50 mA supply. All units operable from −40°C to +60°C, & with supply voltage as low as 12.6 volts. Noise figure is measured at center frequency with 50-ohm source.

NOTES The models listed above are two-stage amplifiers having very broad bandwidth, good output match, low S21•S12 product (−20 dB or less), and low intermodulation. The specified frequency refers to the measurement of parameters. The specified passband is minimum.

Among the amplifier models listed here, the 15-dB (nominal) gain units have their input impedance modified by feedback for the sake of impedance match. The 19-dB and 24-dB (nominal) gain models have an input impedance of about 100 ohms at 30 MHz.


2.880 (7,315)
.100 (0,254)
2.675±.010 (0,025) (6,794)
POWER SUPPLY POSITIVE INPUT VIA FEEDTHROUGH CAPACITOR (SOLDER TERMINAL)
.750 MAX (1,905)
.380 (0,965)
AMPLIFIER MOUNTS TO HEAT SINK ON THIS SURFACE VIA THROUGH-BOLTS
.700 (1,778)
1.835±.010 (4,660) (0,025)
2.040 (5,181)
.580 (1,473)
.970 (2,463)
1.400 (3,556)
+
GND
SMA FEMALE CONNECTOR TYP 2 PLACES (OTHER TYPES AVAILABLE ON REQUEST)
INPUT
DECAL
.120±.010 (0,304) (0,025) DIA THRU 4-HOLES

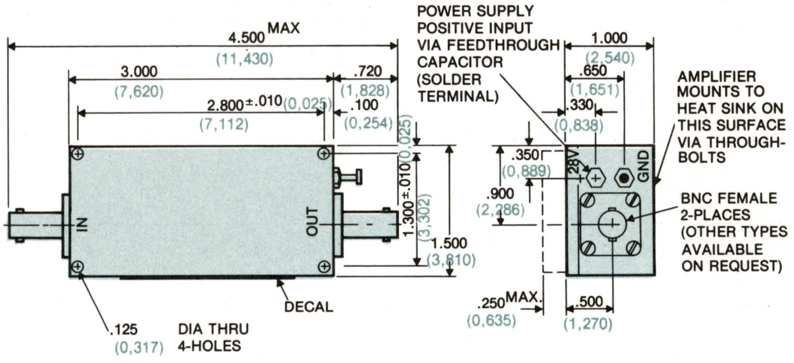
MATERIAL IS IRRIDITED ALUMINUM

PACKAGE CONFIGURATION X

EXPLANATION OF MODEL NUMBERING CODE

O (Where applicable, signifies octave bandwidth) A (Amplifier) - (center frequency) - (nominal gain) - (minimum output in mW at 1-dB compression)

PACKAGE CONFIGURATION (SEE DRAWING)	SOURCE IMPEDANCE (OHMS)	MAXIMUM INPUT VSWR (50-OHM REF.)	MAXIMUM OUTPUT VSWR (50-OHM REF.)	MODEL NUMBER
X	50	No Spec	1.3	A-15-19-30
X	50	No Spec	1.3 @ 15 MHz	OA-15-19-25
X or J	50	No Spec	1.3	A-30-19-30
X or J	50	No Spec	1.3 @ 30 MHz	OA-30-19-30
X or J	50	No Spec	1.3	A-30-24-30
X or J	50	1.5	1.3	A-45-15-30
X or J	50	1.5 @ 45 MHz	1.3 @ 45 MHz	OA-45-15-25
X or J	50/100*	3.0	1.3	A-45-19-30
X or J	50/75*	No Spec	1.3	A-60-19-30
X or J	50	No Spec	1.3	OA-60-19-25
X or J	50	1.5	1.3	A-70-15-50
X or J	50/100*	3.0	1.3	A-70-19-30
X	50/100*	3.0	1.5	A-120-19-30
X	50/100*	3.0	1.5	A-150-19-30


4.500 MAX
(11,430)
3.000
(7,620)
.720
(1,828)
2.800±.010(0,025)
(7,112)
.100
(0,254)
(0,025)
1.300±.010
(3,302)
1.500
(3,810)
IN
OUT
DECAL
.125
(0,317)
DIA THRU
4-HOLES
POWER SUPPLY
POSITIVE INPUT
VIA FEEDTHROUGH
CAPACITOR
(SOLDER
TERMINAL)
1.000
(2,540)
.650
(1,651)
.330
(0,838)
.350
(0,889)
.900
(2,286)
28V
GND
AMPLIFIER
MOUNTS TO
HEAT SINK ON
THIS SURFACE
VIA THROUGH-
BOLTS
BNC FEMALE
2-PLACES
(OTHER TYPES
AVAILABLE
ON REQUEST)
.250 MAX.
(0,635)
.500
(1,270)

MATERIAL IS IRRIDITED ALUMINUM

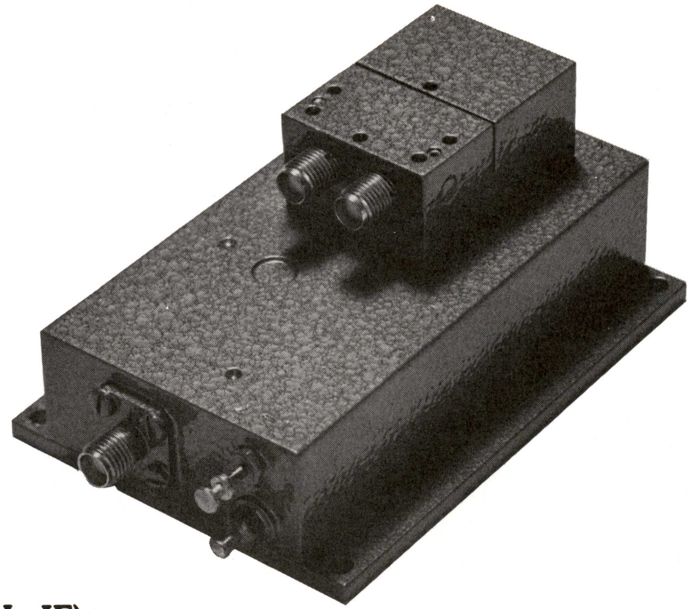
PACKAGE CONFIGURATION J

EXAMPLE: Model A-30-19-30 signifies a unit tested at 30 MHz and having a nominal gain of 19 dB and a minimum output power of 30 milliwatts at 1-dB gain compression.
Model OA-30-19-30 is an octave-bandwidth equivalent of the above design. Its gain is flat to within +0/−1 dB over the octave range of 20 MHz to 40 MHz.
All other parameters for Model OA-30-19-30 would be specified at the center frequency.

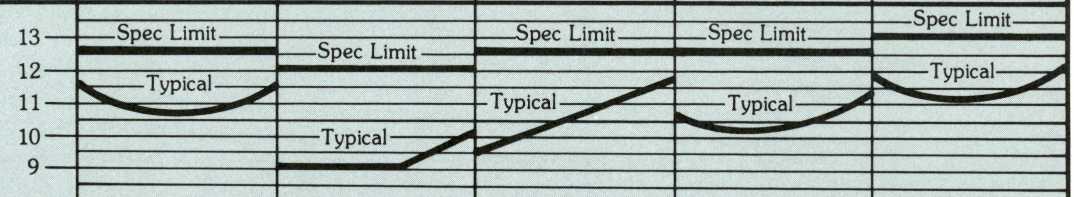
HIGH IF MIXER-PREAMPLIFIERS ... A SERIES FEATURING LOW NOISE FIGURE AND LOW INTERMODULATION FROM 1-18 GHz.

DESCRIPTION

The Sage MP series of high IF mixer-preamplifiers enables you to select any of our miniature M-LINE mixers from 1 GHz to 18 GHz and one of our 750 MHz IF pre-amplifiers. We will assemble and peak them for your required performance. The table below shows the electrical performance of these units. Shown on the facing page is a table of noise figure-intermodulation options which we offer. If you have any questions that are not answered by this data, we invite you to call and discuss the matter with our engineers.



ELECTRICAL SPECIFICATIONS (750 MHz IF)

MODEL NO →	MPL 750 A 15	MPS 750 A 15	MPC 750 A 15	MPX 750 A 15	MPK 750 A 15
NOISE FIGURE (dB)					
SIGNAL FREQUENCY (GHz)	1-2	2-4	4-8	8-12	12-18
MAX. VSWR	2.5	1.75	2.0	1.75	2.0
MIN. ISOLATION (dB)	20	8	7	8	6
IF CENTER FREQ. (MHz)	750	750	750	750	750

MODEL NUMBER EXAMPLE

MPL	750	A	15
↓	↓	↓	↓
Signal Frequency	IF Center Frequency	Noise Figure-Intermod. Option (see facing page)	Preamp. Supply Voltage (Note 4)

NOTES (COMMON TO ALL MODELS)

1. LO power: +10 dBm
2. LO frequency above signal frequency
3. RF-IF gain: 10 dB minimum (includes mixer conversion loss)
4. Please indicate preferred pre-amp. supply voltage (standards are 15VDC and 28VDC).

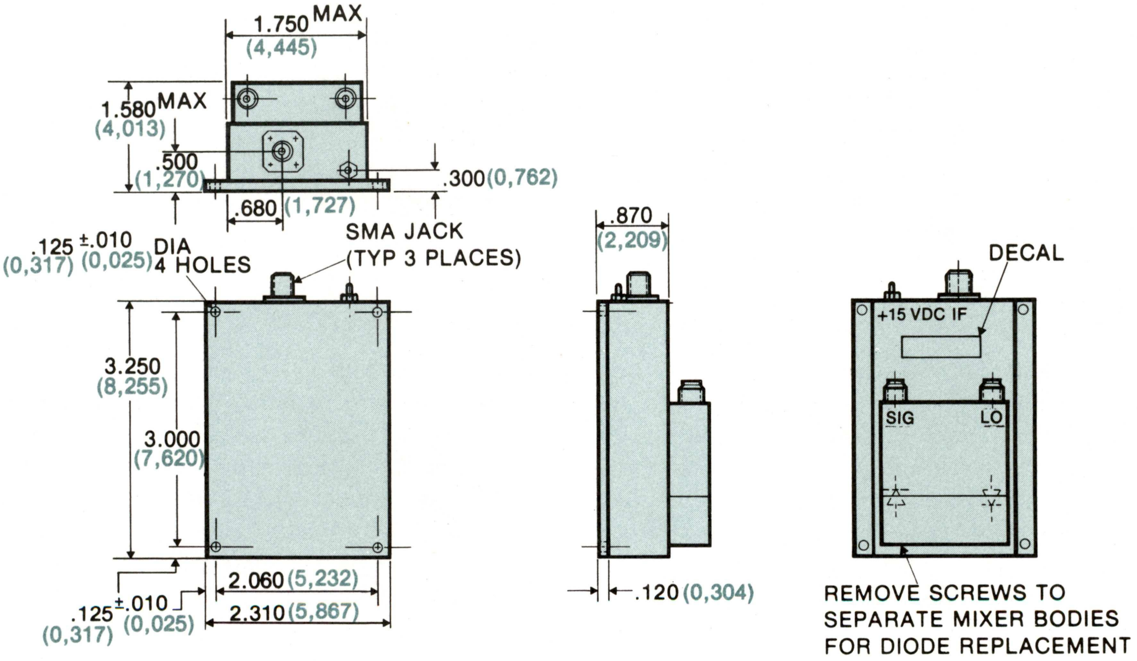
sage®
LABORATORIES · INC
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

STANDARD IF CHARACTERISTICS

Center Frequency	750 MHz
1-dB Minimum Bandwidth	150 MHz
3-dB Passband	600-900 MHz
3-dB Minimum Bandwidth	300 MHz

NOISE FIGURE-INTERMODULATION OPTIONS	NOMINAL CURRENT (MA)	NOISE FIGURE	3rd ORDER INTERCEPT POINT (dBm, min.)
(A) Standard Unit	45	per graph	+15
(B) Optimized Noise Figure	15	−1 dB	+10
(C) Optimized 3rd Order IM	60	+1 dB	+25

MECHANICAL DATA


1.750 MAX
(4,445)
1.580 MAX
(4,013)
.500
(1,270)
.300 (0,762)
.680 (1,727)
.125 ±.010 DIA
(0,317) (0,025) 4 HOLES
SMA JACK
(TYP 3 PLACES)
3.250
(8,255)
3.000
(7,620)
2.060 (5,232)
2.310 (5,867)
.125 ±.010
(0,317) (0,025)
.870
(2,209)
.120 (0,304)
DECAL
+15 VDC IF
SIG
LO
REMOVE SCREWS TO
SEPARATE MIXER BODIES
FOR DIODE REPLACEMENT

MATERIALS & FINISHES

Aluminum construction, finished in Sage Hammertone Green paint.

sage

LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

APPLICATION NOTES VHF & UHF AMPLIFIERS & PRE-AMPLIFIERS

GENERAL TEST METHODS FOR SAGE AMPLIFIERS

- Unless otherwise specified, the noise figures given in the standard product tables are based on the HP series of 50-ohm diode-source Automatic Noise Figure meters.
- Customers often burn out the inputs of amplifiers by attempting to test input VSWR with an instrument which injects too high a power level. *Do not attempt to use a rhotector or other high level measurement device.* Input VSWR should be measured at a level low enough so that the amplifier is operating in its linear range (e.g., less than −40 dBm incident power for Model A-30-50-50-1). Terminate the output.

  CAUTION: *At no time should the input level exceed +10 dBm.*
- The output VSWR can be measured at 0 dBm. Remember that there is wide-band noise at the output. Terminate the input. For some designs, the output reactance changes quickly with frequency. Check the frequency of measurement.
- Amplifier gain may change a decibel or more with each one-volt change in supply voltage. Nominal 28-volt amplifiers will operate from 15 volts with good noise figure, but the gain will be reduced. Most amplifiers require external heat sinking. For continuous operation, the amplifier case temperature should be kept below 40°C (104°F). Do not operate the amplifier at higher than nominal supply voltage.
- Avoid operating the amplifier with the output unloaded or unterminated. Certain lengths of unterminated cable on the input and/or the output may cause the amplifier to oscillate.
- Do not apply reverse supply voltage. Do not patch the output to the input. Do not apply DC or 60 Hz voltage to the input or output jacks.

NUCLEAR MAGNETIC RESEARCH & OTHER LABORATORY APPLICATIONS

One use of HF wide-band low noise amplifiers is in Nuclear Magnetic Research (NMR) and other laboratory techniques in which RF pulses are applied to a sample (often unknown) material, and the echoes, spin echoes, or other emissions from the excited sample are measured. In order to read decay time and to find small effects, the amplifier must return to a steady state immediately after the test excitation is stopped. One of our standard amplifiers which meets such requirements is Model A15-60-1C-3. This unit has good match and low noise figure, and it will recover to within 0.2 dB of normal in a microsecond. The bandwidth is 10 MHz. (The low frequency response is a limiting factor here. Unless balanced stages are used, the overload transients couple through the amplifier.) To cover wider ranges, you could order two or more units with similar specifications.

Many solid state amplifiers (and the components in them) have thermal recovery problems. Their thermal time-constants range from one to 100 microseconds, and of course, such amplifiers will not be useful for several time-constants after a large overload. If recovery is important to your application, you should specify it, and we will include a test to check it.

SPECIAL GAIN CHARACTERISTICS

Feedback amplifiers such as the A(__)-19-30 types tend to maintain fairly constant gain over variations of temperature and supply voltage. For some applications, you may find it desirable to have the amplifier's gain vary upward with increasing temperature, or to be constant over wide temperature ranges. This requires testing (slow, therefore costly) and perhaps a second adjustment and test (more cost), but it can be done if you need it.

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3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

COAXIAL BALANCED MIXERS

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A Guide to Mixer Selection **82**
Custom Engineering Capabilities **83-85**
Standard Products **86-103**
Application Notes **104-108**

A GUIDE TO MIXER SELECTION

All standard mixers shown in this edition of the Sage catalog are coaxial units derived from single balanced mixers using quadrature hybrids. The outstanding attribute of the quadrature hybrid balanced mixer is low RF and LO VSWR. Mixers of this type have normal LO noise cancellation properties and simple low loss RF circuits.

All Sage mixers are designed so that you can easily replace diodes in the field. (Complete instructions for diode replacement are presented at the end of the Application Notes section.) Available in every frequency range are dual IF output mixers, which enable you to build in your own diode performance monitor circuits, and to apply DC bias to the diodes for starved LO operation. Through proper installation of the diodes, you can also operate these mixers as modulators or up-converters. (Details on diode monitoring, starved LO operation, and operation in the modulator and up-converter modes are included in the Application Notes section.)

Mixers generally are specified in terms of RF frequency, IF frequency, noise figure (or conversion loss), VSWR, isolation, and LO operating power level.

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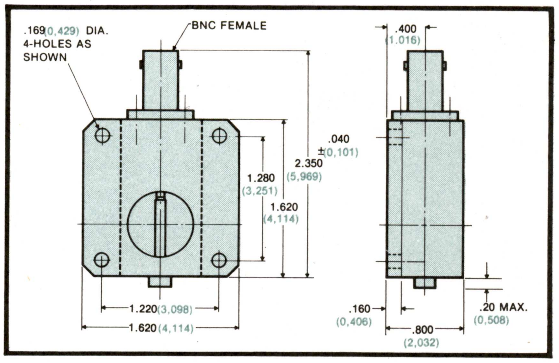
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL BALANCED MIXERS

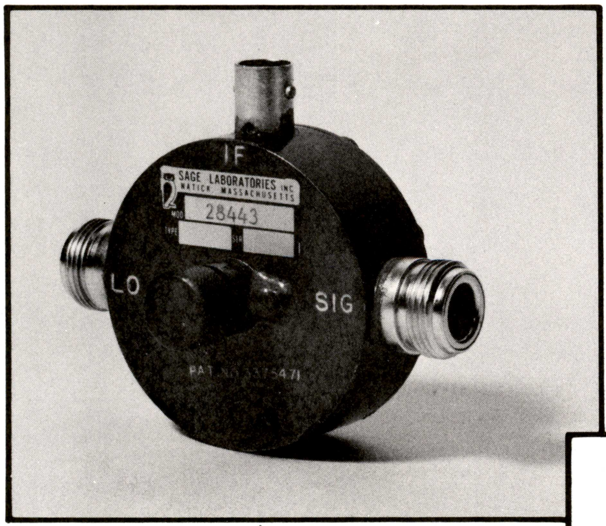
Since 1955, Sage Laboratories has developed special mixers for applications ranging from police radar to deep space probes. A selection of the unclassified designs is presented here. Engineering inquiries are invited.

INEXPENSIVE SINGLE-DIODE WAVEGUIDE DETECTOR FOR POLICE RADAR

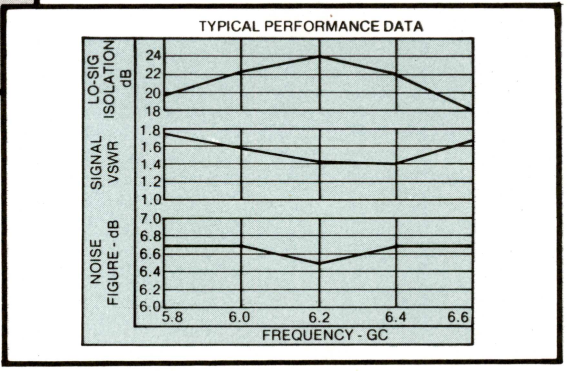
Model: FD1706
Frequency: 10,525 ± 25 MHz
Power: 3 to 6 milliwatts
VSWR: 2.5:1 maximum
DC Load: 470 ohms
Output: positive


.169(0,429) DIA.
4-HOLES AS
SHOWN
BNC FEMALE
.400
(1.016)
.040
±(0,101)
2.350
(5,969)
1.280
(3,251)
1.620
(4,114)
1.220(3,098)
1.620(4,114)
.160
(0,406)
.800
(2,032)
.20 MAX.
(0,508)

TRIMODE TYPE COAXIAL BALANCED MIXERS


IF
SAGE LABORATORIES INC
NATICK MASSACHUSETTS
28443
LO
SIG

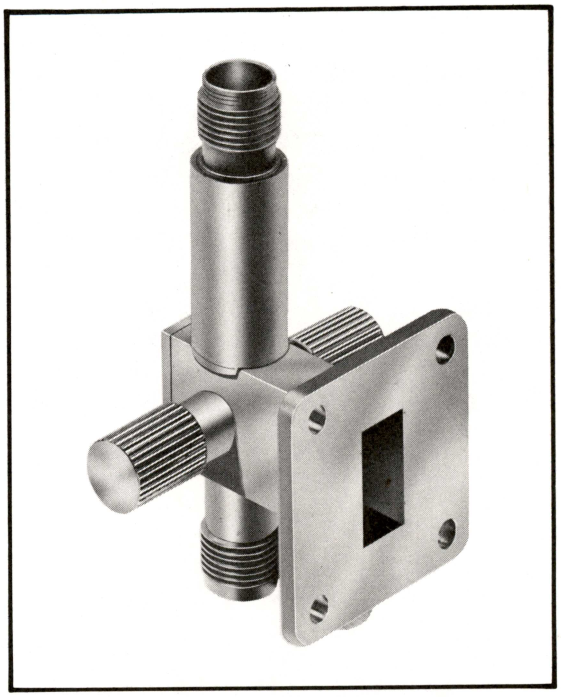
These low cost mixers were designed for multi-channel applications such as phased-array radar, where cost & size were critical factors. They have proven themselves to be compact, lightweight units providing excellent electrical performance in a rugged, reliable package. The unit pictured was designed for an operating range of 5.8-6.6 GHz. It was useable about 20% beyond the rated range. The typical performance curves shown were measured using 1N23E/ER diodes and an IF pre-amplifier with a noise figure of 1.5 dB. This design features inherently high LO to RF isolation and a maximum noise figure of 7.0 dB.



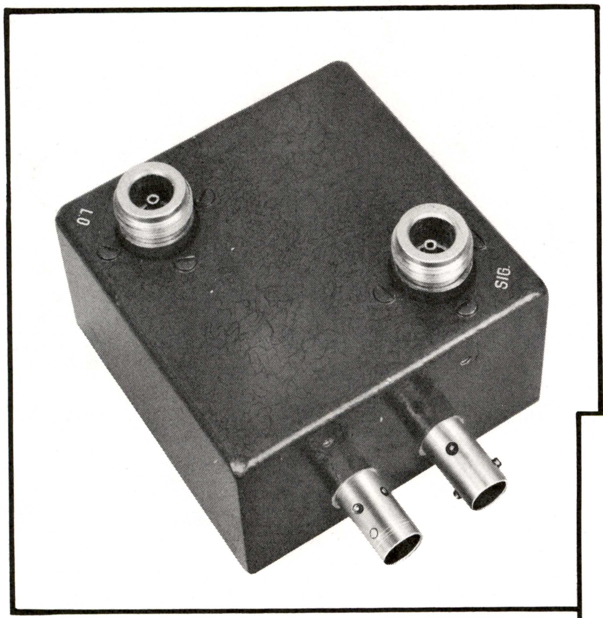
CUSTOM ENGINEERING CAPABILITIES IN COAXIAL BALANCED MIXERS (Continued)

CROSSBAR TYPE WAVEGUIDE BALANCED MIXERS

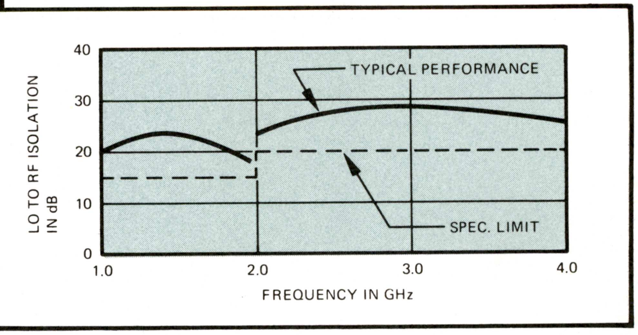
Sage has designed crossbar mixers for (largely) MIL requirements from 4-30 GHz. These designs feature broad frequency range, low noise figure, and high LO to RF isolation. IF frequencies have ranged from 30 MHz to 6.6 GHz. LO to RF isolation was typically 20 dB. Representative of the crossbar designs developed by Sage is the 227K, which operated over the RF range of 15.6-16.4 GHz, had an IF frequency of 6.6 GHz, maximum conversion loss of 10 dB, maximum signal and LO VSWR of 1.8, and a minimum LO to RF isolation of 20 dB. Lower IF designs had noise figures in the range of 7.0 dB.



MAGIC TEE COAXIAL BALANCED MIXERS

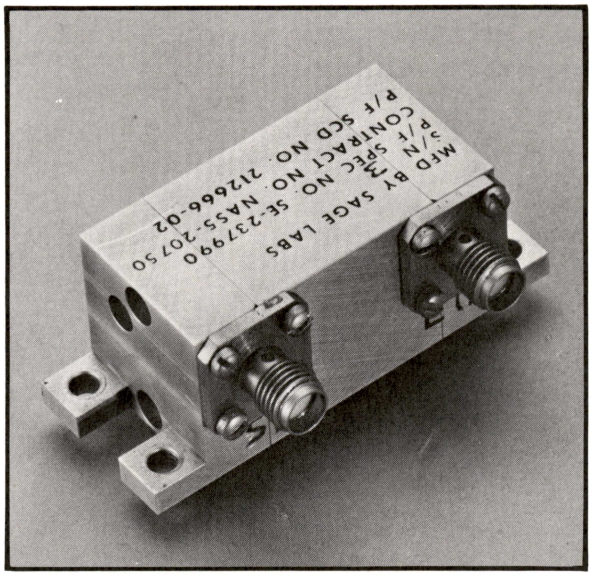


Magic tee designs have been developed which cover 1-4 GHz in two octave-band steps. These designs feature high LO-to-signal isolation, which significantly reduces filter requirements in any application. Size, cost, closely reproducible phase characteristics, and high reliability make these designs ideal for multi-channel applications such as phased-array radar. IFs as high as 1500 MHz have been supplied. The LO power requirements of these designs are typically 1 to 2 milliwatts.



CUSTOM ENGINEERING CAPABILITIES IN COAXIAL BALANCED MIXERS (Continued)

HIGH RELIABILITY MIXERS & UP-CONVERTERS FOR SATELLITE & DEEP SPACE APPLICATIONS

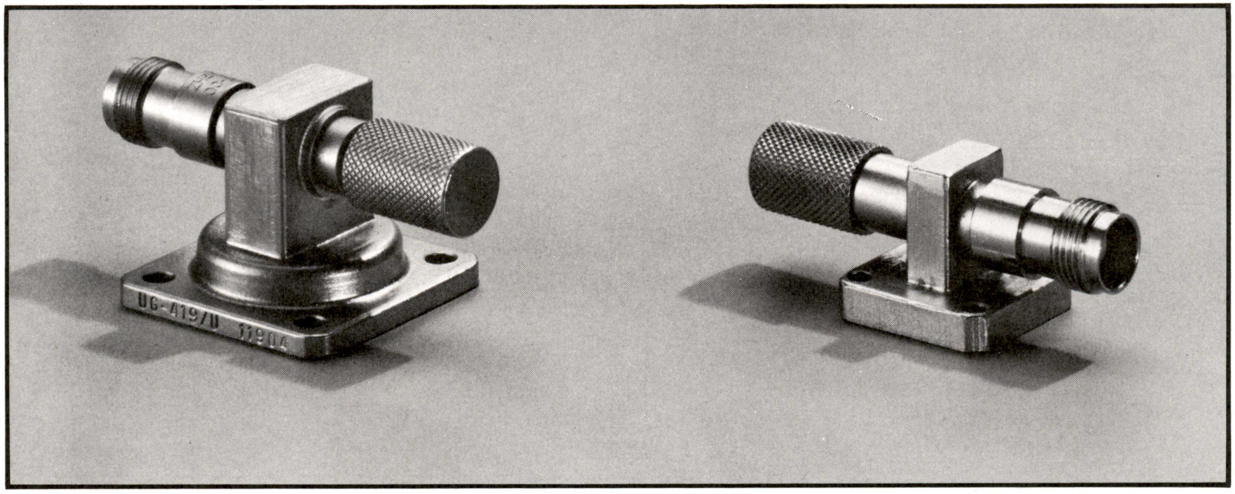


FM670-1A BALANCED MIXERS (DOWN-CONVERTERS) shown at right, were developed for a satellite communications program. Operating RF was 2030 MHz. Maximum VSWR at the RF and LO inputs, respectively, are 1.3:1 and 1.5:1. Noise figure is 7.0 dB maximum, and minimum isolation is 8 dB. For the same program, Sage also supplied FM670-2A UP-CONVERTERS (same configuration as shown at right), designed for an RF operating frequency of 1690 MHz (1600 MHz LO). Maximum conversion loss is 9.0 dB, and isolation is 8 dB minimum. Maximum VSWR at the RF and LO inputs, respectively, are 1.3:1 and 1.5:1.

Similar mixers and up-converters were developed by Sage Laboratories for the Viking Mars probe and the Lunar Module (LM).

SINGLE-DIODE MIXERS FOR INSTRUMENTS

For a leading manufacturer of microwave spectrum analyzers, Sage Laboratories developed the following series of harmonic single-diode coaxial and waveguide mixers.



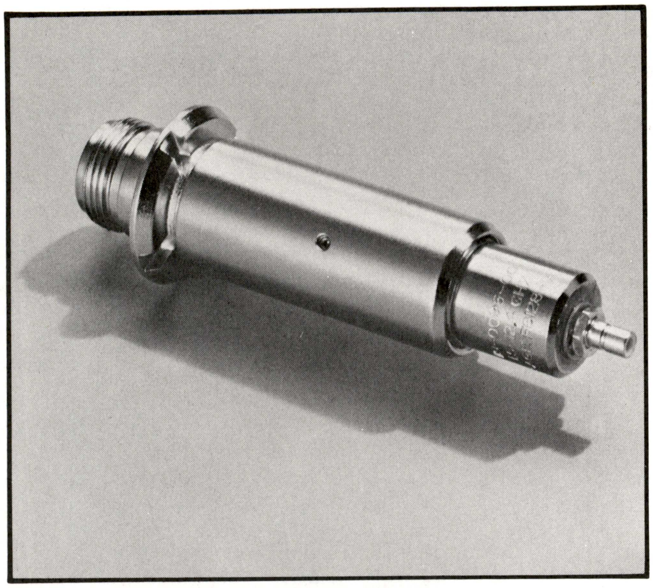
MODEL F6128-2

RF	12.4-18 GHz
RF Power	−40 dBm
LO	2.52-3.64 GHz
LO Power	10 mW Min.
LO Harmonic	5
Sensitivity	−70 dBm Min.
Flatness	±1.5 dB/100 MHz
DC Bias Resistance	450 Ohms

MODEL F6128-3

RF	18.0-26.5 GHz
RF Power	−40 dBm
LO	1.82-2.67 GHz
LO Power	10 mW Min.
LO Harmonic	10
Sensitivity	−65 dBm Min.
Flatness	1.5 dB/100 MHz
DC Bias Resistance	0 Ohms

CUSTOM ENGINEERING CAPABILITIES IN COAXIAL BALANCED MIXERS (Continued)



SINGLE-DIODE MIXERS FOR INSTRUMENTS (Continued)

MODEL F6128-1A

RF	1.5-12.4 GHz
RF Power	−30 dBm
LO	1.7-4.2 GHz
LO Power	10 mW Min.

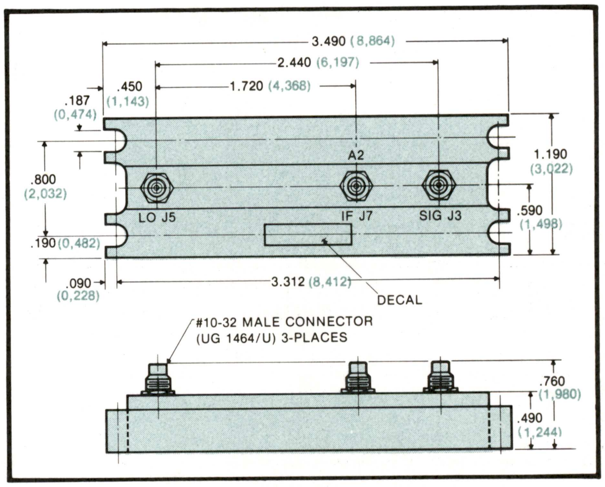
LO HARMONICS		SENSITIVITY
1st	1.5-4.0 GHz	−90 dBm Min.
2nd	3.8-8.2 GHz	−85 dBm Min.
3rd	8.0-12.4 GHz	−75 dBm Min.

Flatness	1.5 dB/100 MHz

DC Bias Resistance: 0 ohms all bands except 2 K-ohms for 3.7-8.2 GHz band.

STRIPLINE BALANCED MIXERS FOR TACAN

VSWR (Signal: 962-1213 MHz)	2.8:1 Max.
VSWR (LO: 1025-1150 MHz)	3:1 Max.
LO/Signal Isolation	18 dB Min.
Noise Figure	6.5 dB Max. (1.5 dB IF)
LO Power	6 mW Max.
Signal Power	−20 dBm


3.490 (8,864)
2.440 (6,197)
1.720 (4,368)
.450 (1,143)
.187 (0,474)
A2
1.190 (3,022)
.800 (2,032)
LO J5
IF J7
SIG J3
.590 (1,498)
.190 (0,482)
.090 (0,228)
3.312 (8,412)
DECAL
#10-32 MALE CONNECTOR (UG 1464/U) 3-PLACES
.760 (1,980)
.490 (1,244)

MIXER-AMPLIFIER COMBINATIONS

We have chosen to locate examples of our custom engineering capabilities in mixer-amplifiers in the AMPLIFIER section. By procuring your mixers and amplifiers as factory-combined assemblies, you can avoid many interface problems, obtain superior performance, and save money in the long haul.

sage
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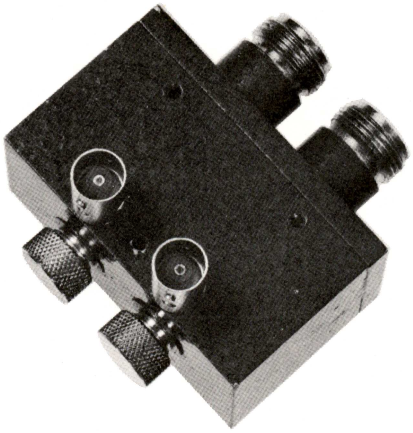
TEMLINE®
OCTAVE BAND
COAXIAL BALANCED MIXERS
(125 MHz to 8 GHz)

FEATURES

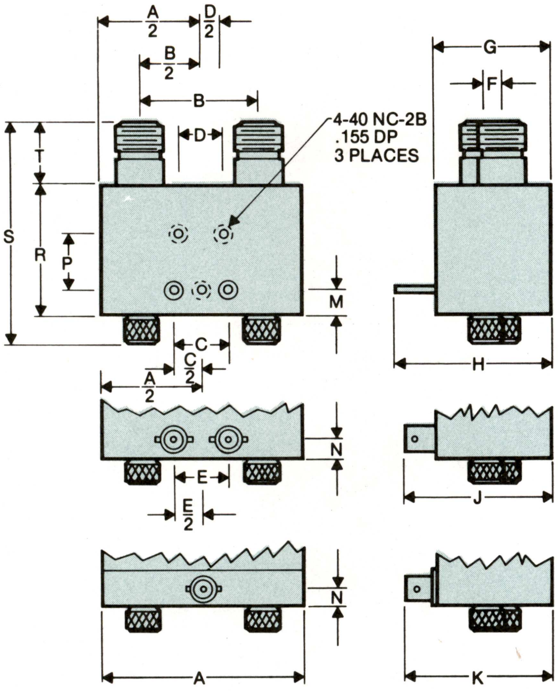
- octave-band coverage from 125-8000 MHz
- field-replaceable point-contact cartridge diodes
- economical, rugged units
- low noise figure
- can be used as up-converters (signal into one RF port, modulation frequency into IF port; upper & lower sidebands then available at other RF port)



ELECTRICAL SPECIFICATIONS (Measured with + 3 dBM LO power)

MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	OPERATING FREQUENCY RANGE
2491A	Dual Solder Pin	1.5	8.5	125-250 MHz
2491	Dual BNC	1.5	8.5	125-250 MHz
2493	Single BNC	1.5	8.5	125-250 MHz
2501A	Dual Solder Pin	1.5	8.5	250-500 MHz
2501	Dual BNC	1.5	8.5	250-500 MHz
2503	Single BNC	1.5	8.5	250-500 MHz
2511A	Dual Solder Pin	1.5	8.5	500-1000 MHz
2511	Dual BNC	1.5	8.5	500-1000 MHz
2513	Single BNC	1.5	8.5	500-1000 MHz
2521A	Dual Solder Pin	1.5	8.5	1.0-2.0 GHz
2521	Dual BNC	1.5	8.5	1.0-2.0 GHz
2523	Single BNC	1.5	8.5	1.0-2.0 GHz
2531A	Dual Solder Pin	1.5	8.0	2.0-4.0 GHz
2531	Dual BNC	1.5	8.0	2.0-4.0 GHz
2533	Single BNC	1.5	8.0	2.0-4.0 GHz
2541NDA	Dual Solder Pin	1.7	8.5	4.0-8.0 GHz
2541ND	Dual BNC	1.7	8.5	4.0-8.0 GHz
2543ND	Single BNC	1.7	8.5	4.0-8.0 GHz

TEMLINE® COAXIAL BALANCED MIXERS
MECHANICAL DATA



NOTES:
(1) Mounting holes normally provided on solder pin units only
(2) RF connectors, type N female
(3) All solder pins, 1/16" diameter

MODEL NO.	A	B	C	D	E	F	G	H	J	K	M	N	P	R	S	T
2491A	11.69	11	1.40	1.25	–	.10	1.38	2.0	–	–	.19	–	.90	1.42	2.52	.72
2491	11.69	11	–	–	1.40	.10	1.38	–	2.01	–	–	.19	–	1.42	2.52	.72
2493	11.69	11	–	–	–	.10	1.38	–	–	2.0	–	.19	–	1.42	2.52	.72
2501A	6.31	5.63	1.41	1.25	–	.10	1.38	2.0	–	–	.19	–	.90	1.42	2.52	.72
2501	6.31	5.63	–	–	1.41	.10	1.38	–	2.0	–	–	.19	–	1.42	2.52	.72
2503	6.31	5.63	–	–	–	.10	1.38	–	–	1.94	–	.19	–	1.42	2.52	.72
2511A	3.47	2.78	1.41	1.25	–	.10	1.38	2.0	–	–	.19	–	.90	1.42	2.52	.72
2511	3.47	2.78	–	–	1.41	.10	1.38	–	2.0	–	–	.19	–	1.42	2.52	.72
2513	3.47	2.78	–	–	–	.10	1.38	–	–	1.94	–	.19	–	1.42	2.52	.72
2521A	2.38	1.41	1.41	1.25	–	.10	1.38	2.0	–	–	.19	–	.90	1.42	2.52	.72
2521	2.38	1.41	–	–	1.41	.10	1.38	–	2.0	–	–	.19	–	1.42	2.52	.72
2523	2.38	1.41	–	–	–	.10	1.38	–	–	1.94	–	.19	–	1.42	2.52	.72
2531A	2.38	.83	.83	1.25	–	.10	1.38	2.0	–	–	.19	–	.90	1.42	2.52	.72
2531	2.38	.83	–	–	.83	.10	1.38	–	2.0	–	–	.19	–	1.42	2.52	.72
2533	2.38	.83	–	–	–	.10	1.38	–	–	1.94	–	.19	–	1.42	2.52	.72
2541NDA	1.5	.83	.83	1.25	–	.37	1.27	2.0	–	–	.25	–	.90	1.76	2.66	.65
2541ND	1.5	.83	–	–	.83	.37	1.27	–	1.89	–	–	.25	–	1.76	2.66	.65
2543ND	1.5	.83	–	–	–	.37	1.27	–	–	2.07	–	.25	–	1.76	2.66	.65

MATERIALS & FINISHES

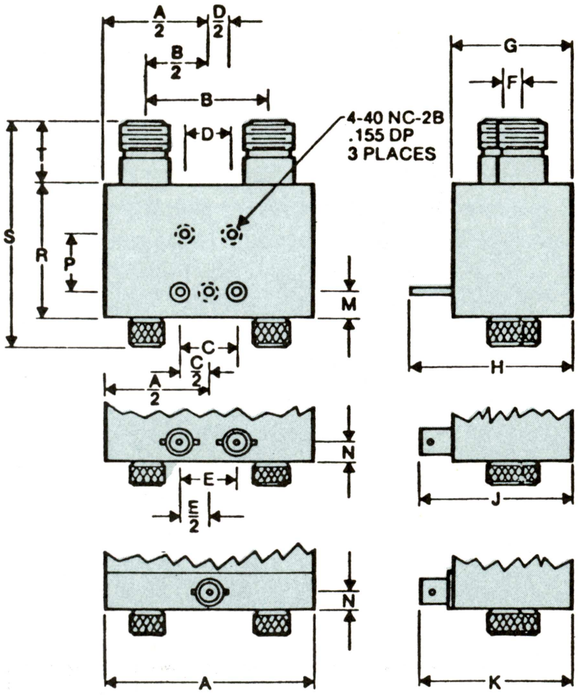
Bodies: Aluminum (Painted Sage Hammertone Green)

Coax Contacts (Beryllium Copper) & Connectors (Brass): Silver-plated & Rhodium-Flashed

All Sageline Materials & Finishes to Government Specs.

Alternative Materials & Finishes on Special Order

TEMLINE® COAXIAL BALANCED MIXERS
MECHANICAL DATA



NOTES:

(1) Mounting holes normally provided on solder pin units only

(2) RF connectors, type N female

(3) All solder pins, 1/16" diameter

DIMENSIONS IN CENTIMETERS

MODEL NO.	A	B	C	D	E	F	G	H	J	K	M	N	P	R	S	T
2491A	(29,686)	(27,934)	(3,555)	(3,174)		(0,253)	(3,504)	(5,079)			(0,482)		(2,285)	(3,606)	(6,399)	(1,828)
2491	(29,686)	(27,934)			(3,555)	(0,253)	(3,504)		(5,104)			(0,482)		(3.606)	(6,399)	(1,828)
2493	(29,686)	(27,934)				(0,253)	(3,504)			(5,079)		(0,482)		(3,606)	(6,399)	(1,828)
2501A	(16,024)	(14,297)	(3,580)	(3,174)		(0,253)	(3,504)	(5,079)			(0,482)		(2,285)	(3,606)	(6,399)	(1,828)
2501	(16,024)	(14,297)			(3,580)	(0,253)	(3,504)		(5,079)			(0,482)		(3,606)	(6,399)	(1.828)
2503	(16,024)	(14,297)				(0,253)	(3,504)			(4,926)		(0,482)		(3,606)	(6,399)	(1,828)
2511A	(8,812)	(7,059)	(3,580)	(3,174)		(0,253)	(3,504)	(5,079)			(0,482)		(2,285)	(3,606)	(6,399)	(1,828)
2511	(8,812)	(7,059)			(3,580)	(0,253)	(3,504)		(5,079)			(0,482)		(3,606)	(6,399)	(1,828)
2513	(8,812)	(7,059)				(0,253)	(3,504)			(4,926)		(0,482)		(3,606)	(6,399)	(1,828)
2521A	(6,044)	(3,580)	(3,580)	(3,174)		(0,253)	(3,504)	(5,079)			(0,482)		(2,285)	(3,606)	(6,399)	(1,828)
2521	(6,044)	(3,580)			(3,580)	(0,253)	(3,504)		(5,079)			(0,482)		(3,606)	(6,399)	(1,828)
2523	(6,044)	(3,580)				(0,253)	(3,504)			(4,926)		(0,482)		(3,606)	(6,399)	(1,828)
2531A	(6,044)	(2,107)	(2,107)	(3,174)		(0,253)	(3,504)	(5,079)			(0,482)		(2,285)	(3,606)	(6,399)	(1,828)
2531	(6,044)	(2,107)			(2,107)	(0,253)	(3,504)		(5,079)			(0,482)		(3,606)	(6,399)	(1,828)
2533	(6,044)	(2,107)				(0,253)	(3,504)			(4,926)		(0,482)		(3,606)	(6,399)	(1,828)
2541NDA	(3,809)	(2,107)	(2,107)	(3,174)		(0,939)	(3,225)	(5,079)			(0,634)		(2,286)	(4,469)	(6,755)	(1,650)
2541ND	(3,809)	(2,107)			(2,107)	(0,939)	(3,225)		(4,799)			(0,634)		(4,469)	(6,755)	(1,650)
2543ND	(3,809)	(2,107)				(0,939)	(3,225)			(5,256)		(0,634)		(4,469)	(6,755)	(1,650)

MATERIALS & FINISHES

Bodies: Aluminum (Painted Sage Hammertone Green)
Coax Contacts (Beryllium Copper) & Connectors (Brass): Silver-plated & Rhodium-Flashed

All Sageline Materials & Finishes to Government Specs.
Alternative Materials & Finishes on Special Order

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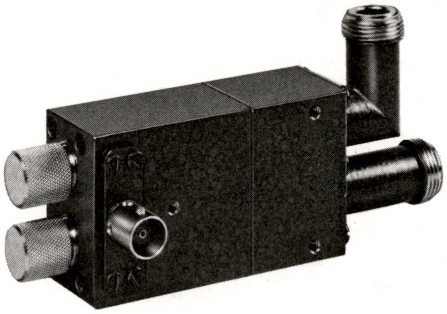
TEMLINE® OCTAVE BAND COAXIAL BALANCED MIXERS (8-12 GHz)

FEATURES

- broadband performance (8-12 GHz)
- field-replaceable coaxial diodes
- low noise figure
- IF solder pins available for direct mounting to IF preamplifier
- IF performance through 120 MHz standard
- rugged, economical units

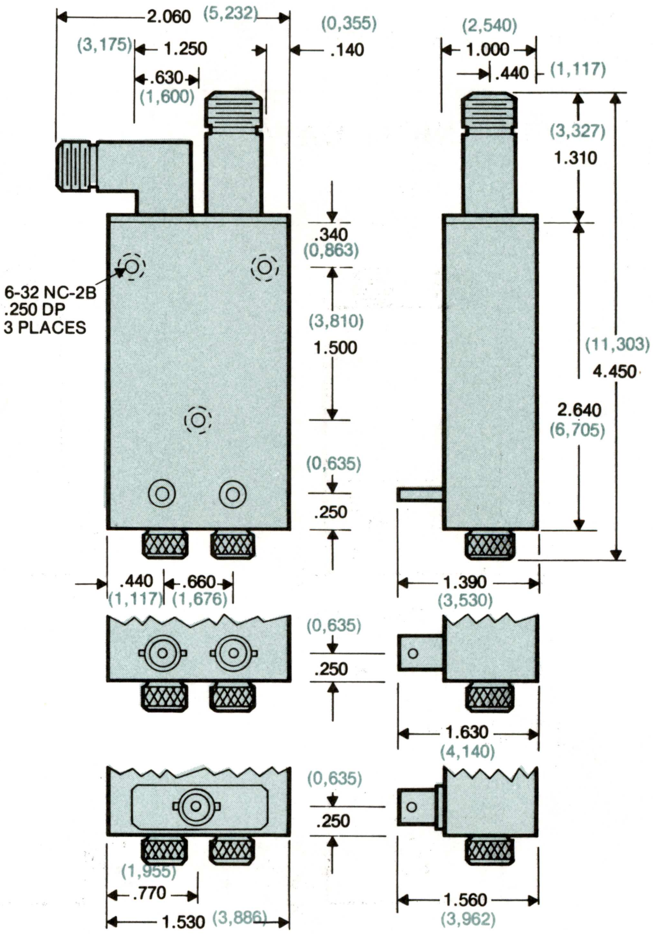


ELECTRICAL SPECIFICATIONS

(Measured with + 3 dBm LO power)

MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)
2551A	Dual Solder Lug	3.0	10
2551	Dual BNC	3.0	10
2553	Single BNC	3.0	10

MECHANICAL DATA


2.060 (5,232)
(3,175) 1.250
.630 (1,600)
(0,355) .140
(2,540) 1.000
.440 (1,117)
(3,327) 1.310
.340 (0,863)
6-32 NC-2B
.250 DP
3 PLACES
(3,810) 1.500
(11,303) 4.450
2.640 (6,705)
(0,635) .250
.440 (1,117)
.660 (1,676)
1.390 (3,530)
(0,635) .250
1.630 (4,140)
(0,635) .250
(1,955) .770
1.530 (3,886)
1.560 (3,962)

MATERIALS & FINISHES

Bodies: Aluminum (painted Sage Hammertone Green)
Coax Contacts (Beryllium Copper) & Connectors (Brass): Silver-plated & Rhodium-Flashed

All Sageline Materials & Finishes to Government Specs.
Alternative Materials & Finishes on Special Order

NOTES: (1) RF CONNECTORS, TYPE N FEMALE
(2) SOLDER PINS, 1/16 DIA.

sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (0.5-1 GHz)

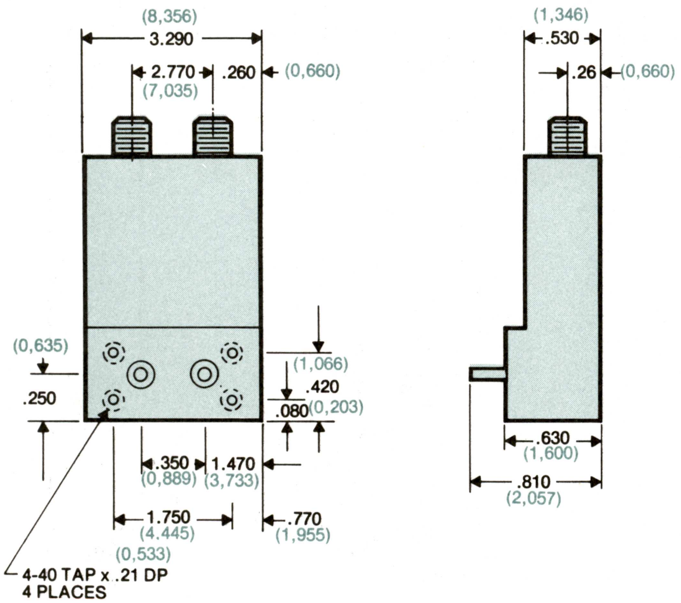
FEATURES

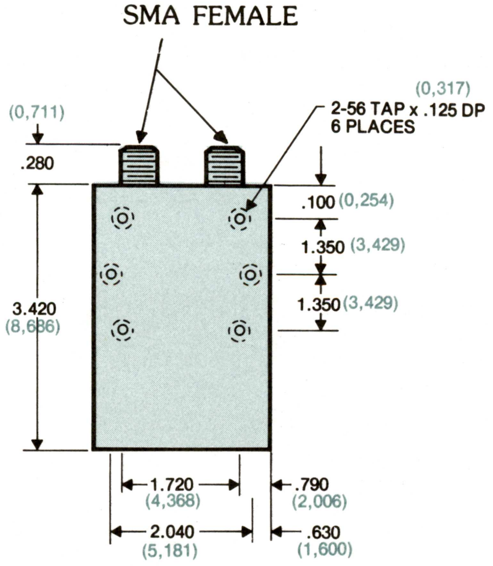
- octave bandwidth
- low noise figure
- IF performance through 200 MHz
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see opening pages of Mixer section)
- Schottky diodes (Alpha D5503) all models - field replaceable

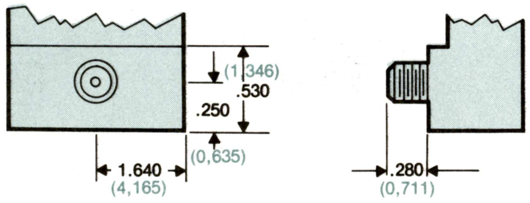
(See Application Notes, end of Mixer section)

SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
MOD. 22513
SER. 119
PAT. NO. 3368246

MECHANICAL DATA


(8,356)
3.290
2.770
(7,035)
.260
(0,660)
(0,635)
.250
(1,066)
.420
.080
(0,203)
.350
(0,889)
1.470
(3,733)
1.750
(4,445)
.770
(1,955)
(0,533)
4-40 TAP x .21 DP
4 PLACES
(1,346)
.530
.26
(0,660)
.630
(1,600)
.810
(2,057)

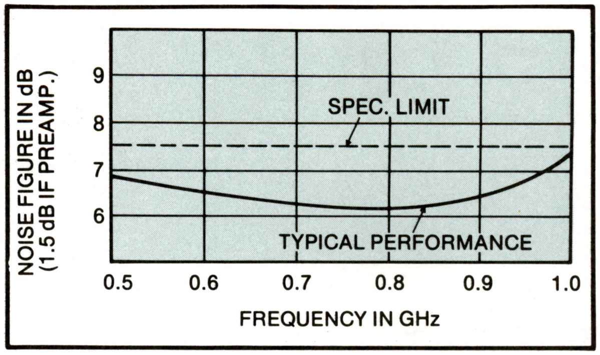

SMA FEMALE
(0,711)
.280
(0,317)
2-56 TAP x .125 DP
6 PLACES
.100 (0,254)
1.350 (3,429)
1.350 (3,429)
3.420
(8,686)
1.720
(4,368)
.790
(2,006)
2.040
(5,181)
.630
(1,600)


(1,346)
.530
.250
(0,635)
1.640
(4,165)
.280
(0,711)

MATERIALS & FINISHES

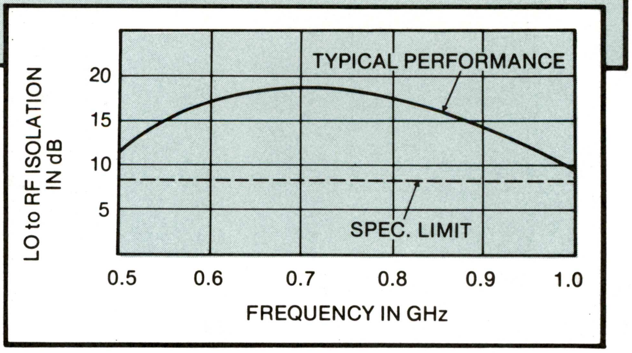
Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

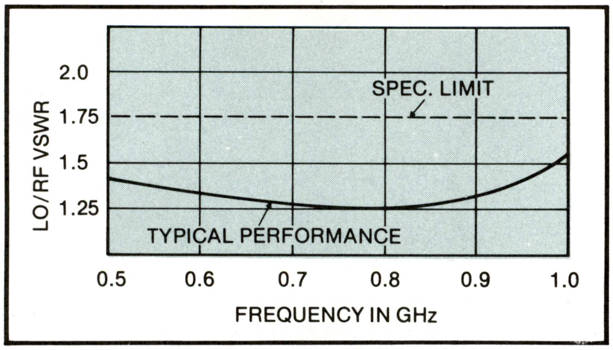
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22511A	Dual Solder Lug	1.75	7.5	–	8.0	80
22511AS	Dual Solder Lug	1.75	–	8.0	7.0	200
22513	Single SMA	1.75	7.5	–	8.0	80
22513S	Single SMA	1.75	–	8.0	7.0	200

NOTES: (1) Can be furnished with point contact diodes on special request. (specs will change)
(2) LO Power required, +6 dBM nominal





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LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (1-2 GHz)

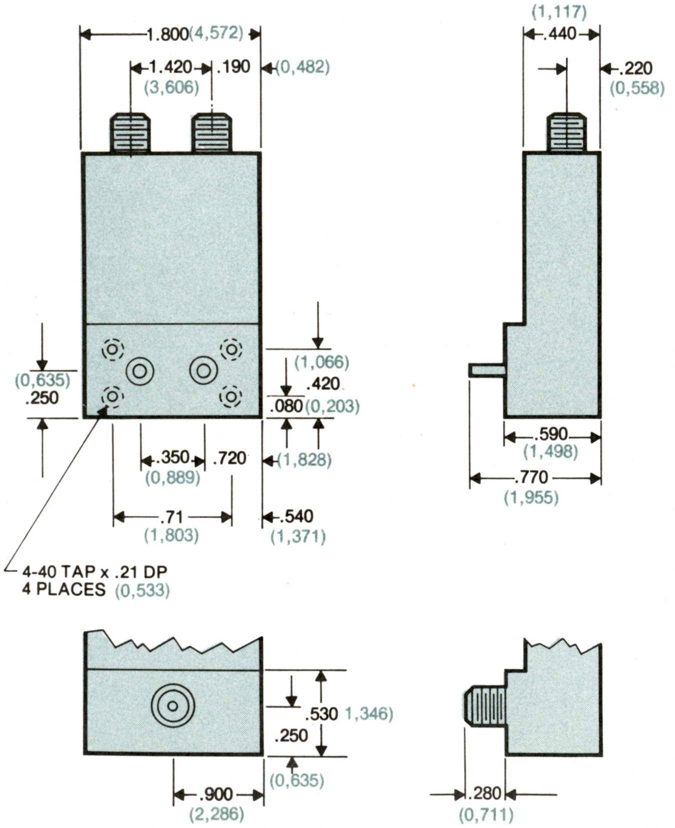
FEATURES

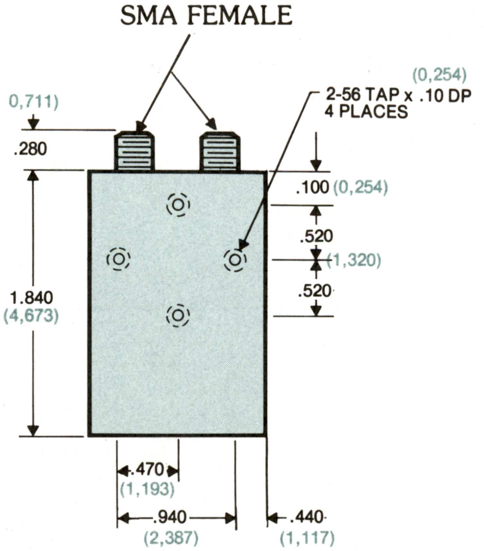
- octave bandwidth
- low noise figure
- IF performance through 500 MHz
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see opening pages of Mixer section)
- Schottky diodes (Alpha D5503) all models - field replaceable

(See Application Notes, end of Mixer section)

SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
MOD
22521A
TYPE
SER
102
PAT. NO. 3358248

MECHANICAL DATA

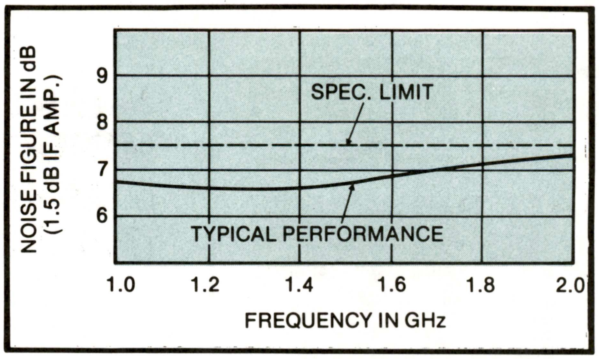

1.800 (4,572)
1.420 (3,606)
.190 (0,482)
(1,117)
.440
.220 (0,558)
(0,635) .250
(1,066)
.420
.080 (0,203)
.350 (0,889)
.720 (1,828)
.71 (1,803)
.540 (1,371)
.590 (1,498)
.770 (1,955)
4-40 TAP x .21 DP
4 PLACES (0,533)
.530 1,346)
.250
(0,635)
.900 (2,286)
.280 (0,711)


SMA FEMALE
(0,254)
2-56 TAP x .10 DP
4 PLACES
0,711)
.280
.100 (0,254)
.520
(1,320)
.520
1.840 (4,673)
.470 (1,193)
.940 (2,387)
.440 (1,117)

MATERIALS & FINISHES

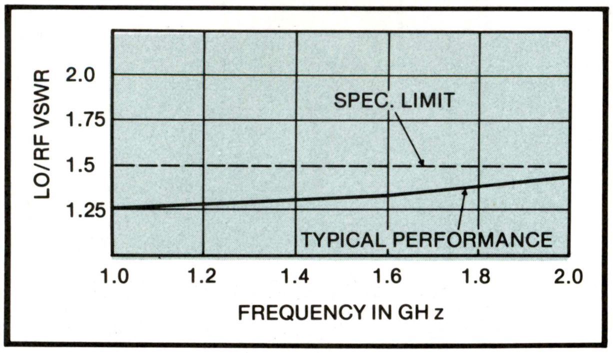
Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

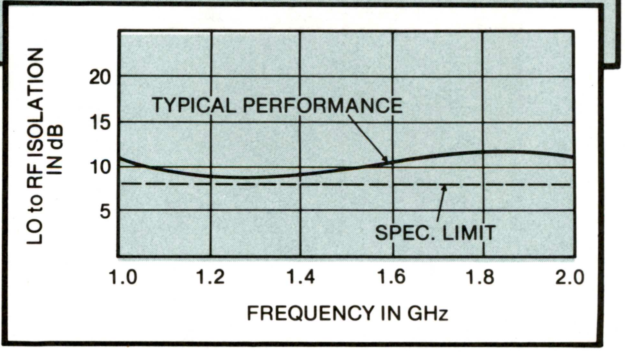
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22521A	Dual Solder Pins	1.5	7.5	–	8.0	100
22521AS	Dual Solder Pins	1.5	–	6.5	7.0	250
22521AT	Dual Solder Pins	1.5	–	6.5	7.0	500
22523	Single SMA	1.5	7.5	–	8.0	100
22523S	Single SMA	1.5	–	6.5	7.0	250
22523T	Single SMA	1.5	–	6.5	7.0	500

NOTES: (1) Can be furnished with point contact diodes on special request. (specs will change)
(2) LO Power required, +6 dBM nominal





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M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (1.4-2.3 GHz)

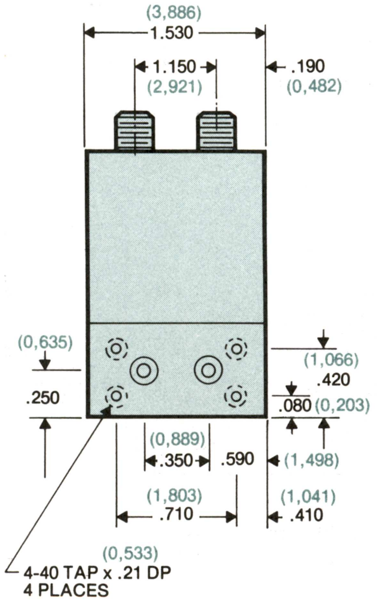
FEATURES

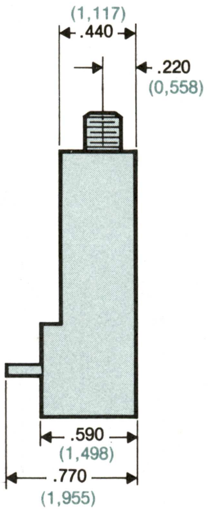
- low noise figure
- IF performance through 500 MHz
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see opening pages of Mixer section)
- Schottky diodes (Sage B4-5865) all models - field replaceable

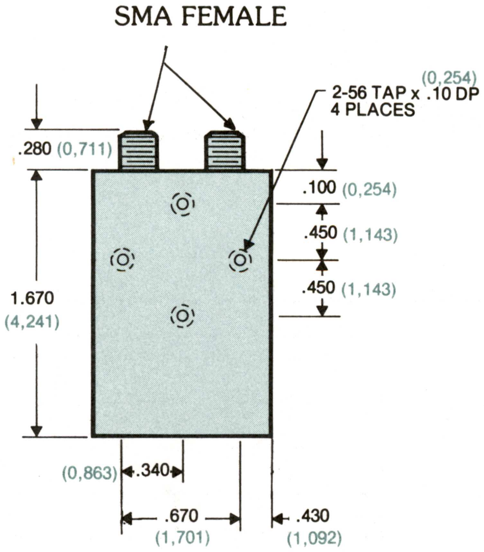
(See Application Notes, end of Mixer section)

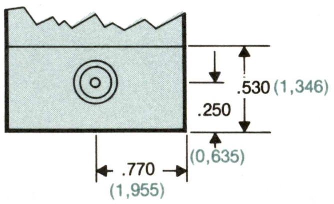
SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
MOD
22523E
TYPE
SER
133
PAT. NO. 3358248

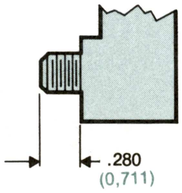
MECHANICAL DATA


(3,886)
1.530
1.150
(2,921)
.190
(0,482)
(0,635)
.250
(1,066)
.420
.080 (0,203)
(0,889)
.350
.590
(1,498)
(1,803)
.710
(1,041)
.410
(0,533)
4-40 TAP x .21 DP
4 PLACES


(1,117)
.440
.220
(0,558)
.590
(1,498)
.770
(1,955)


SMA FEMALE
(0,254)
2-56 TAP x .10 DP
4 PLACES
.280 (0,711)
.100 (0,254)
.450 (1,143)
.450 (1,143)
1.670
(4,241)
(0,863)
.340
.670
(1,701)
.430
(1,092)

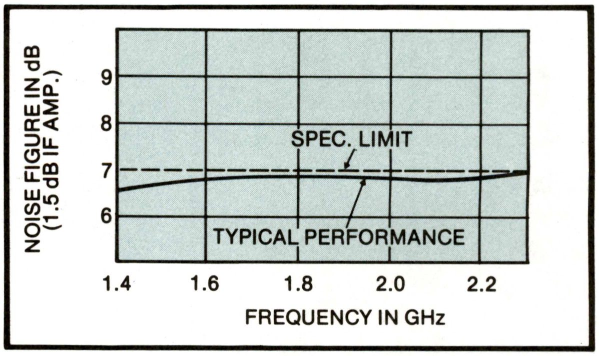

.530 (1,346)
.250
(0,635)
.770
(1,955)



MATERIALS & FINISHES

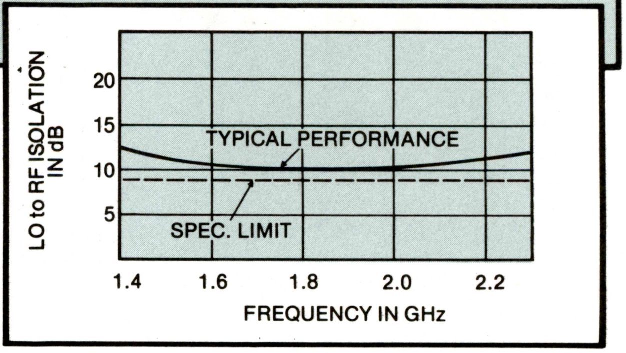
Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

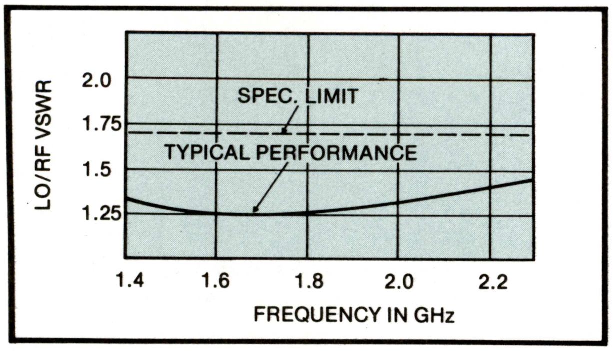
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22521EA	Dual Solder Pin	1.7	7.0	–	9.0	100
22521EAS	Dual Solder Pin	1.7	–	6.5	9.0	250
22521EAT	Dual Solder Pin	1.7	–	6.5	9.0	500
22523E	Single SMA	1.7	7.0	–	9.0	100
22523ES	Single SMA	1.7	–	6.5	9.0	250
22523ET	Single SMA	1.7	–	6.5	9.0	500

NOTE: (1) LO Power required, +6 dBM nominal





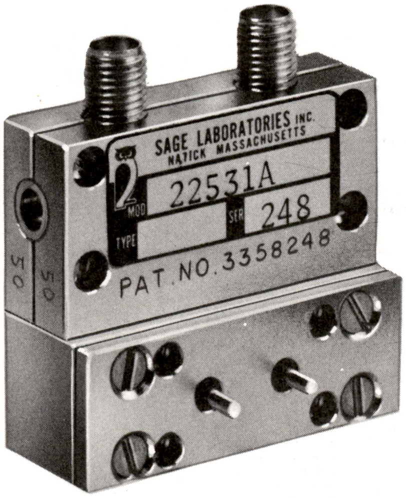
sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (2-4 GHz)

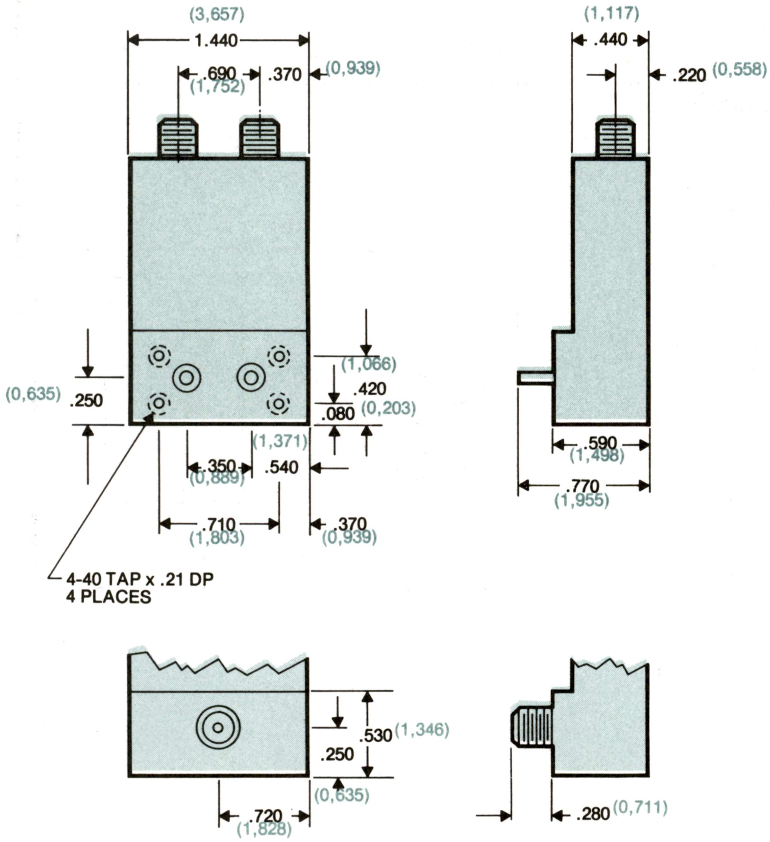
FEATURES

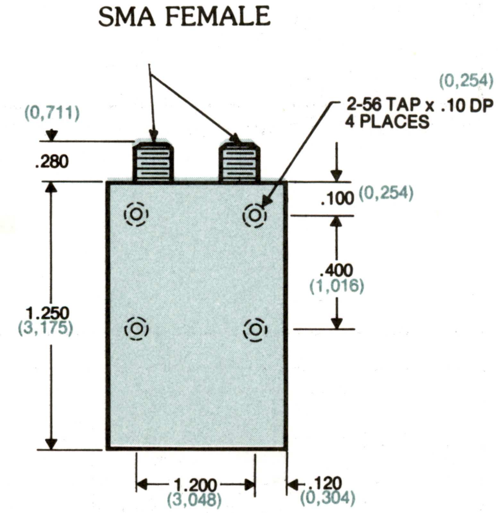
- octave bandwidth
- low noise figure
- IF performance through 500 MHz
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating
- conditions (see opening pages of Mixer section)
- Schottky diodes (Alpha D5506B) all models - field replaceable

(See Application Notes, end of Mixer section)


SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
MOD
22531A
TYPE
SER
248
PAT. NO. 3358248

MECHANICAL DATA

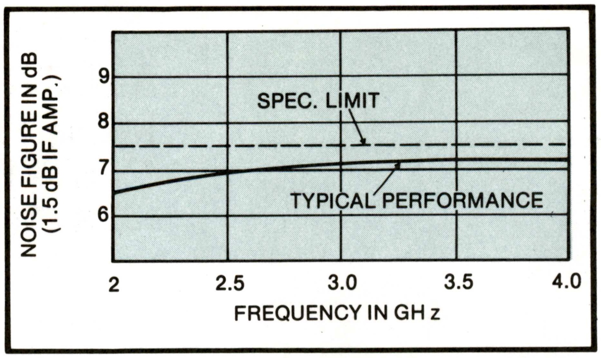

(3,657)
1.440
.690
(1,752)
.370
(0,939)
(1,117)
.440
.220 (0,558)
(1,066)
.420
.080 (0,203)
(0,635)
.250
(1,371)
.350
(0,889)
.540
.710
(1,803)
.370
(0,939)
.590
(1,498)
.770
(1,955)
4-40 TAP x .21 DP
4 PLACES
.530 (1,346)
.250
(0,635)
.720
(1,828)
.280 (0,711)


SMA FEMALE
(0,254)
2-56 TAP x .10 DP
4 PLACES
(0,711)
.280
.100 (0,254)
.400
(1,016)
1.250
(3,175)
1.200
(3,048)
.120
(0,304)

MATERIALS & FINISHES

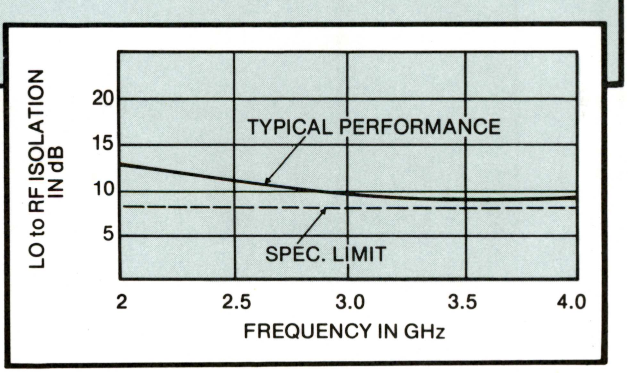
Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

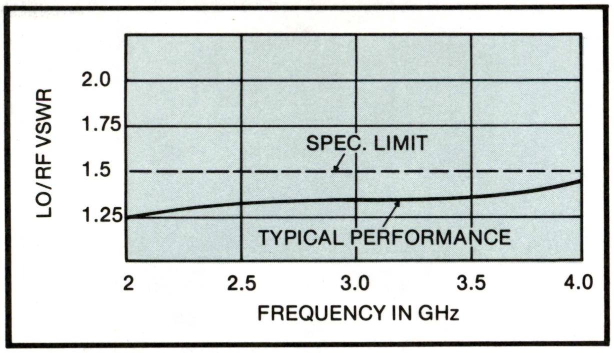
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22531A	Dual Solder Pin	1.5	7.5	–	8.0	100
22531AS	Dual Solder Pin	1.5	–	7.0	7.0	250
22531AT	Dual Solder Pin	1.5	–	7.0	7.0	500
22533	Single SMA	1.5	7.5	–	8.0	100
22533S	Single SMA	1.5	–	7.0	7.0	250
22533T	Single SMA	1.5	–	7.0	7.0	500

NOTES: (1) Can be furnished with point contact diodes on special request. (specs will change)
(2) LO Power required, +6 dBM nominal





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M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (4-8 GHz)

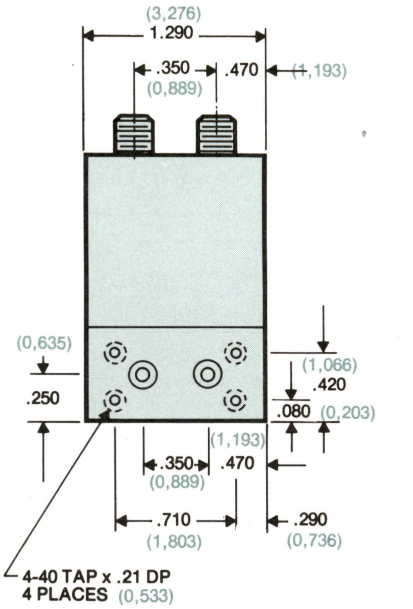
FEATURES

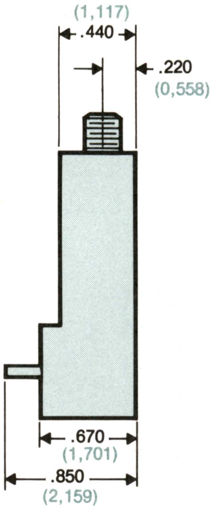
- octave bandwidth
- low noise figure
- IF performance through 750 MHz
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see opening pages of Mixer section)
- Schottky diodes (Alpha D5506B) all models - field replaceable

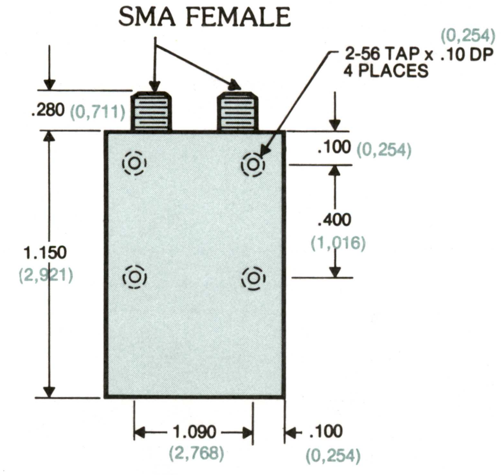
(See Application Notes, end of Mixer section)

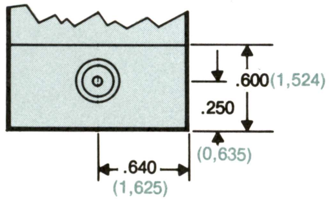
SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
MOD
22541A
TYPE
SER
149

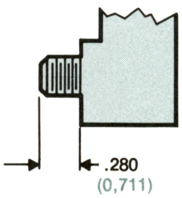
MECHANICAL DATA


(3,276)
1.290
.350
(0,889)
.470
(1,193)
(0,635)
.250
(1,066)
.420
.080
(0,203)
(1,193)
.350
(0,889)
.470
.710
(1,803)
.290
(0,736)
4-40 TAP x .21 DP
4 PLACES (0,533)


(1,117)
.440
.220
(0,558)
.670
(1,701)
.850
(2,159)


SMA FEMALE
(0,254)
2-56 TAP x .10 DP
4 PLACES
.280 (0,711)
.100 (0,254)
.400
(1,016)
1.150
(2,921)
1.090
(2,768)
.100
(0,254)

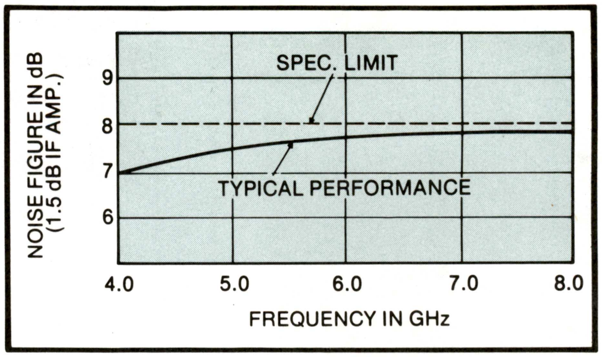

.600(1,524)
.250
(0,635)
.640
(1,625)



MATERIALS & FINISHES

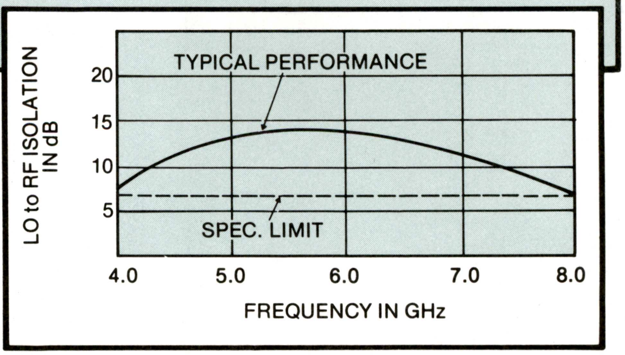
Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

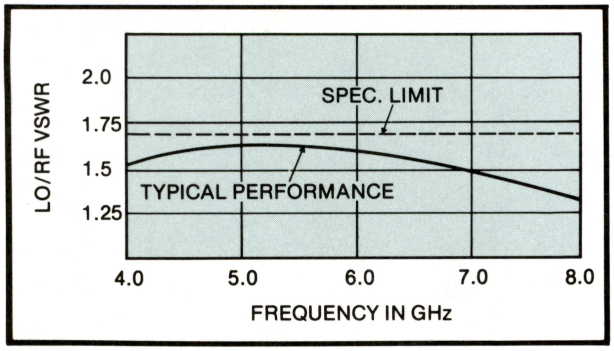
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22541A	Dual Solder Pin	1.7	8.0	–	7.0	160
22541AS	Dual Solder Pin	1.7	–	7.0	6.0	250
22541AT	Dual Solder Pin	1.7	–	7.5	6.0	500
22541AV	Dual Solder Pin	1.7	–	7.5	6.0	750
22543	Single SMA	1.7	8.0	–	7.0	160
22543S	Single SMA	1.7	–	7.0	6.0	250
22543T	Single SMA	1.7	–	7.5	6.0	500
22543V	Single SMA	1.7	–	7.5	6.0	750

NOTES: (1) Can be furnished with point contact diodes on special request. (specs will change)
(2) LO Power required, +6 dBM nominal





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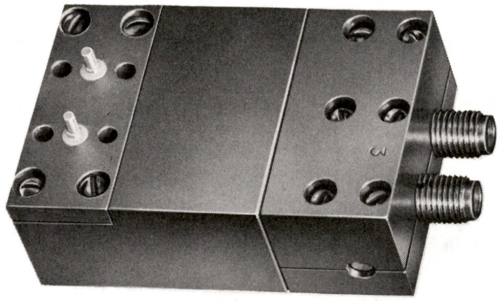
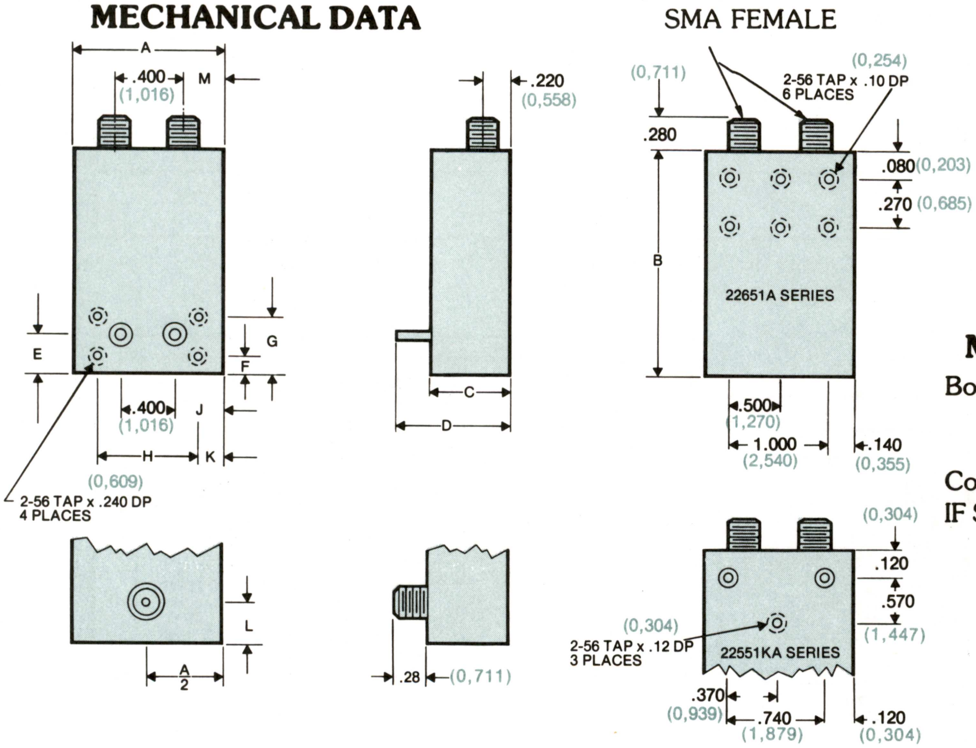
M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (8-12 GHz)

FEATURES

- low noise figure
- IF performance through 1000 MHz
- rugged diode holders - no finger contacts - easy field replacement of diodes (Silicon Schottky - MA40008 or MA 40887) (See Application Notes, end of Mixer section)
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see Application Notes, end of Mixer section) -use MA40887 or MA40646 diodes



MECHANICAL DATA

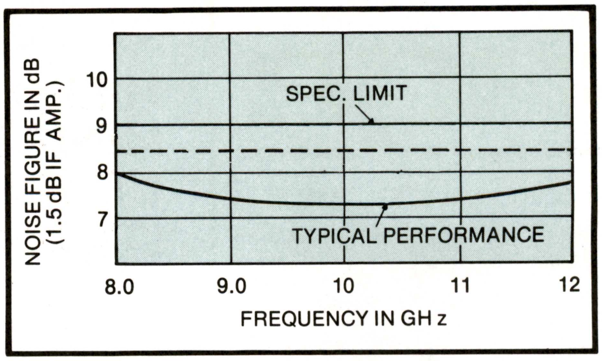

SMA FEMALE
A
.400
(1,016)
M
.220
(0,558)
(0,711)
(0,254)
2-56 TAP x .10 DP
6 PLACES
.280
.080 (0,203)
.270 (0,685)
B
22651A SERIES
E
G
F
.400
(1,016)
J
C
D
H
K
(0,609)
2-56 TAP x .240 DP
4 PLACES
.500
(1,270)
1.000
(2,540)
.140
(0,355)
L
A/2
.28 (0,711)
(0,304)
.120
.570
(1,447)
(0,304)
2-56 TAP x .12 DP
3 PLACES
22551KA SERIES
.370
(0,939)
.740
(1,879)
.120
(0,304)

MATERIALS & FINISHES

Bodies:	Aluminum (Silver-Plate, Rhodium-Flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, Passivated
IF Solder Pins:	Silver-Plated Beryllium Copper

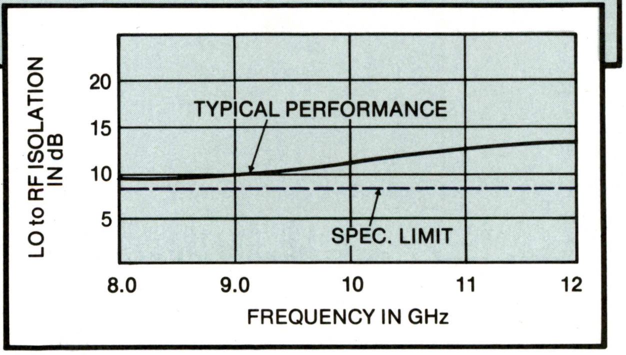
MODEL TYPES	A		B		C		D		E		F		G		H		J		K		L		M	
	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.	inch.	cm.
22551K & 22553K SERIES	.990	(2,514)	1.400	(3,556)	.610	(1,549)	.790	(2,006)	.360	(0,914)	.230	(0,584)	.570	(1,447)	.710	(1,803)	.300	(0,762)	.140	(0,355)	.360	(0,914)	.300	(0,762)
22651A & 22653 SERIES	1.280	(3,251)	1.870	(4,749)	.670	(1,701)	.850	(2,159)	.240	(0,609)	.080	(0,203)	.400	(1,016)	.400	(1,016)	.440	(1,117)	.440	(1,117)	.240	(0,609)	.440	(1,117)

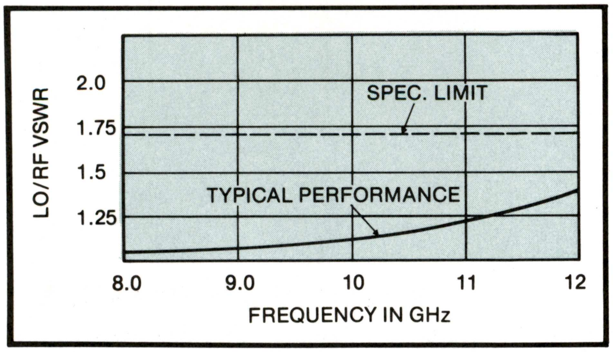
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22551KA	Dual Solder Pin	1.7	8.5	–	6.0	160
22551KAS	Dual Solder Pin	1.7	–	8.0	6.0	250
22551KAT	Dual Solder Pin	1.7	–	8.5	6.0	500
22553K	Single SMA	1.7	8.5	–	6.0	160
22553KS	Single SMA	1.7	–	8.0	6.0	250
22553KT	Single SMA	1.7	–	8.5	6.0	500
22651A	Dual Solder Pin	1.7	8.5	–	8.0	160
22651AS	Dual Solder Pin	1.7	–	7.5	8.0	250
22651AT	Dual Solder Pin	1.7	–	8.0	8.0	500
22651AV	Dual Solder Pin	1.7	–	8.5	8.0	750
22651AW	Dual Solder Pin	1.7	–	9.0	8.0	1000
22653	Single SMA	1.7	8.5	–	8.0	160
22653S	Single SMA	1.7	–	7.5	8.0	250
22653T	Single SMA	1.7	–	8.0	8.0	500
22653V	Single SMA	1.7	–	8.5	8.0	750
22653W	Single SMA	1.7	–	9.0	8.0	1000

NOTE: (1) LO Power required, +6 dBM nominal
(2) LO/RF to IF Isolation: 27 dB minimum





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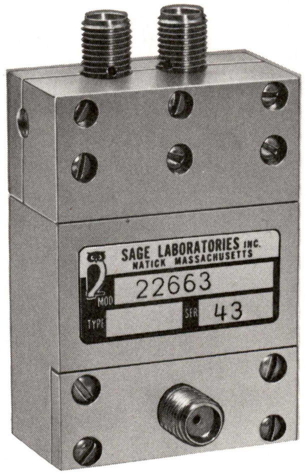
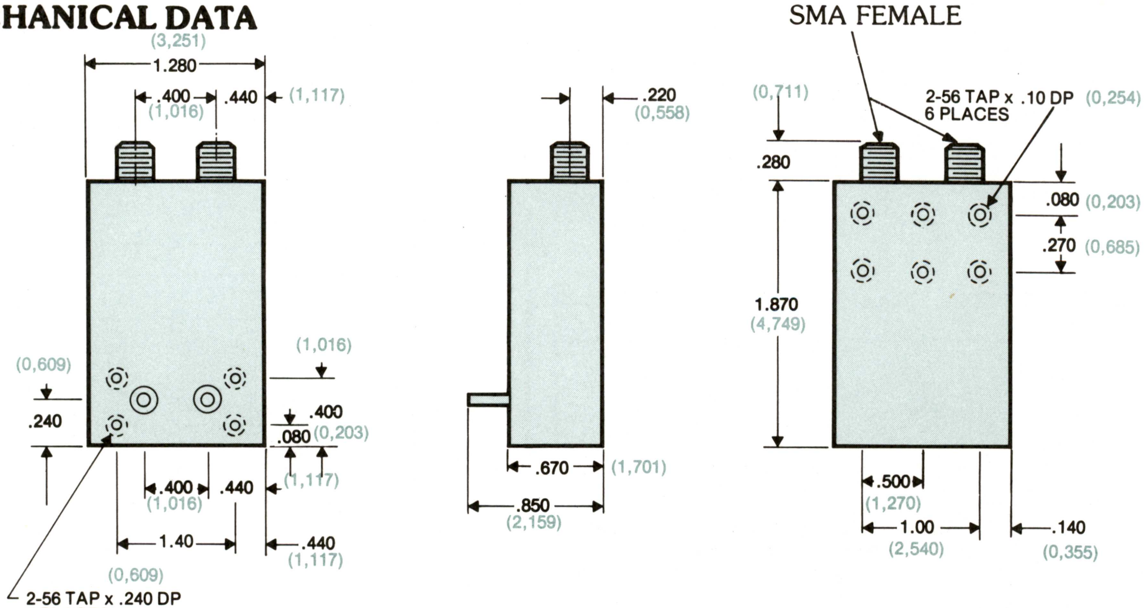
M-LINE™ MINIATURE COAXIAL BALANCED MIXERS (12-18 GHz)

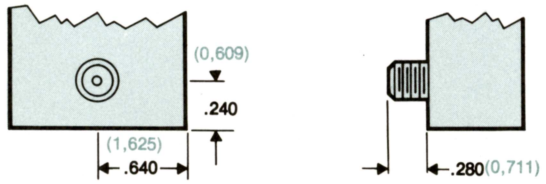
FEATURES

- low noise figure
- IF performance through 750 MHz
- rugged diode holders - no finger contacts - easy field replacement of diodes [(Silicon Schottky MA40617 - (See Application Notes, end of Mixer section)]
- low VSWR
- can also be operated as up-converters (see opening pages of Mixer section)
- solder pin outputs available for direct mounting on IF preamplifiers
- tapped mounting holes provided on all units
- perform well under starved LO operating conditions (see opening pages of Mixer section)


SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
MOD 22663
TYPE
SER 43

MECHANICAL DATA

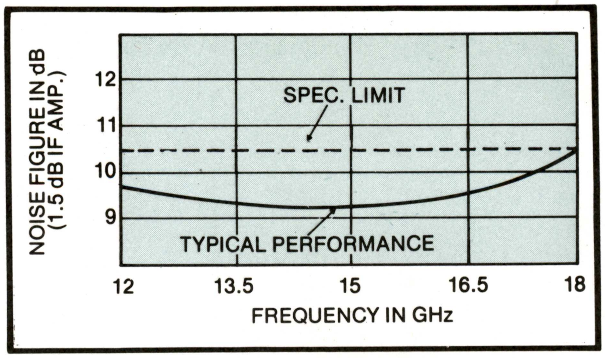

(3,251)
1.280
.400
(1,016)
.440
(1,117)
(0,609)
.240
(1,016)
.400
.080 (0,203)
.400
(1,016)
.440
(1,117)
1.40
.440
(1,117)
(0,609)
2-56 TAP x .240 DP
4 PLACES
.220
(0,558)
.670
(1,701)
.850
(2,159)
SMA FEMALE
(0,711)
.280
2-56 TAP x .10 DP (0,254)
6 PLACES
.080 (0,203)
.270 (0,685)
1.870
(4,749)
.500
(1,270)
1.00
(2,540)
.140
(0,355)


(0,609)
.240
(1,625)
.640
.280 (0,711)

MATERIALS & FINISHES

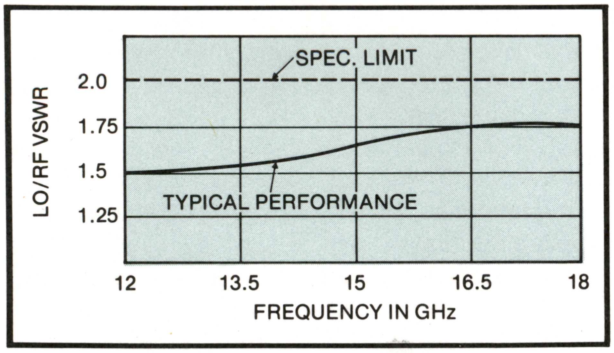
Bodies:	Aluminum (silver-plate, rhodium-flash, painted Sage Hammertone Green)
Connectors:	Stainless Steel, passivated
IF Solder Pins:	Silver-plated beryllium copper

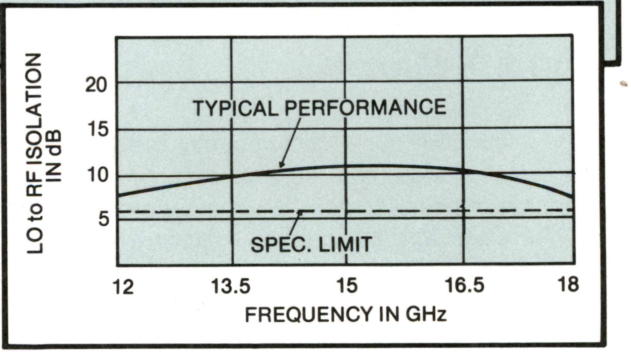
ELECTRICAL SPECIFICATIONS



MODEL NUMBER	IF OUTPUT CONNECTOR	MAXIMUM RF/LO VSWR	MAXIMUM NOISE FIGURE IN dB (1.5 dB IF)	MAXIMUM CONVERSION LOSS IN dB	MINIMUM LO to RF ISOLATION IN dB	MAXIMUM IF FREQUENCY RANGE IN MHz
22661A	Dual Solder Pin	2.0	10.5	–	6.0	160
22661AS	Dual Solder Pin	2.0	–	9.0	6.0	250
22661AT	Dual Solder Pin	2.0	–	9.0	6.0	500
22661AV	Dual Solder Pin	2.0	–	9.5	6.0	750
22663	Single SMA	2.0	10.5	–	6.0	160
22663S	Single SMA	2.0	–	9.0	6.0	250
22663T	Single SMA	2.0	–	9.0	6.0	500
22663V	Single SMA	2.0	–	9.5	6.0	750

NOTE: (1) LO Power required, + 6 dBM nominal





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APPLICATION NOTES COAXIAL BALANCED MIXERS

IF IMPEDANCE VARIATIONS

Reasonably flat IF impedance performance as a function of RF frequency becomes very important when wide IF bandwiths are required. If a change in impedance of 3:1 or even 2:1 is encountered, considerable distortion can occur in the IF bandpass characteristic as RF frequency is varied. This results from the interface coupling network (mixer IF output to amplifier input) being unable to cope with wide variations of input impedance. Even with constant LO power, certain factors can contribute to IF impedance variations. Two such factors are VSWR performance of the diodes and sum-frequency or second harmonic LO termination.

Figure 1 illustrates a plot of the resistive IF impedance component for the Sage Laboratories 22551-22653 series of X-band (8-12 GHz) M-LINE coaxial balanced mixers. This relatively flat performance is typical of the M-LINE mixer series as a whole.

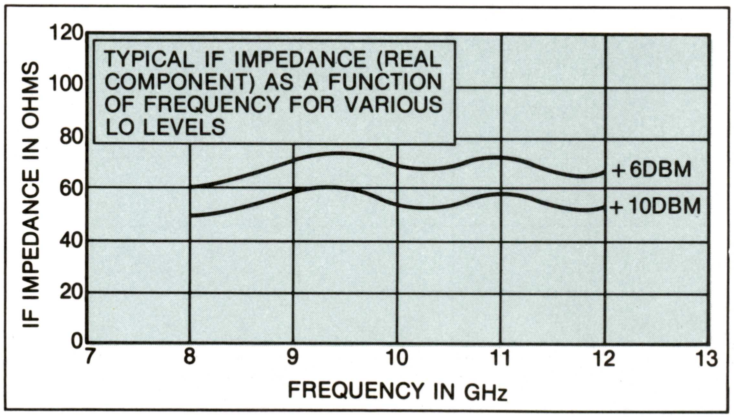


FIGURE 1

HIGH IF OPERATION

High IF operation has become popular as system requirements have become more demanding with regard to image and spurious responses. In situations where a preselector filter precedes the mixer, the use of high IF operation can considerably ease the performance requirements of the filter.

All Sage M-LINE coaxial balanced mixers above 1 GHz are available in high IF versions. In the higher frequency ranges, by using a "classic" filter for RF bypass in place of conventional "brute force" capacitance filtering, we have achieved excellent high IF performance. Standard high IF designs up to 1 GHz are available, and even higher IF models can be supplied on request.

Special attention has been given to reduction of IF output impedance and capacitance in all dual solder pin output models of our mixers. These units are normally mounted directly on the IF preamplifier, and appropriate circuitry is added by the customer to achieve his desired bandwidth performance. This arrangement also enables the customer to monitor individual diode DC current levels.

APPLICATION NOTES - COAXIAL BALANCED MIXERS (CONT'D)

Preventing Excess Conversion Loss Ripple at High IFs

Whenever you design into your system mixers having IFs of 1 GHz or higher, you should be on the lookout for excess conversion loss ripple caused by interaction of the impedance of the RF and LO ports with the IF signal. Figure 2 illustrates an equivalent circuit for the IF path through either diode (one half of a balanced mixer).

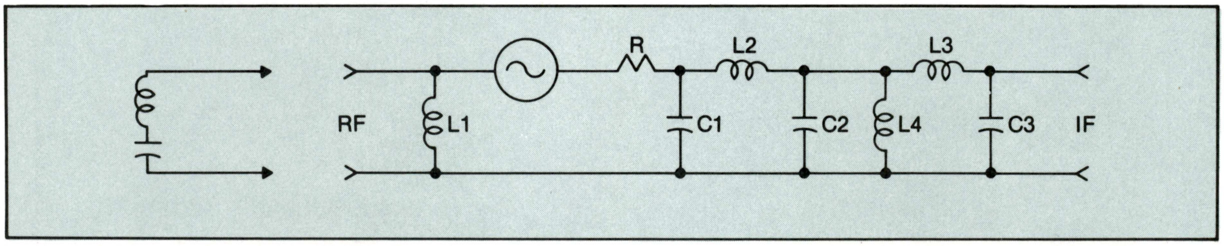


FIGURE 2

At the IF frequency, the diode is replaced by a voltage source with an impedance R. C1, C2, C3 and L2, L3 form a low pass filter for the IF signal. L4 is a matching element and DC return for the diode.

L1 is a small inductor (approximately 0.09 inch length of 0.004 inch diameter wire at Ku-band) which provides a return path for the IF signal and a DC return for the diode, while blocking the RF signal. Although L1 is small, it is not zero. Any high-Q circuit, resonant at the IF frequency, which is connected to the RF port will change the voltage delivered to the IF port.

For example, if you were using a Ku-band mixer with a 1 to 2 GHz IF, you might well find that the use of Ku-band waveguide-to-coax transitions would cause a narrowband spike with considerable increase in conversion loss at a resonant IF frequency. This could happen because the transitions form high-Q bandstop filters in the IF frequency range. Generally, you could correct the condition with a change of line length to K-band components presenting low loss reactive terminations of the IF signal to shift the response out of the band of interest. If you cannot vary line length sufficiently, selective loss may be a practical approach. For example, two Ku-band 3-dB TEM hybrids could be cascaded as a simple diplexer to achieve low loss at Ku-band and to terminate the IF in a matched load.

MONITORING MIXER DIODE CURRENT

Figure 3 shows an effective circuit for the monitoring of mixer diode current. (NOTE: If you plan to monitor diode current, be sure to order mixers with dual solder pin IF outputs.)

The values of C1, L1, C2 and L2 in Figure 3 should be chosen to diplex DC diode current and the IF signal. For best performance, the diode current meter resistance should be less than 10 ohms. The diodes are shown installed for normal down-converter mixer operation. For up-conversion (modulation), reverse one diode so that both have the same polarity.

APPLICATION NOTES - COAXIAL BALANCED MIXERS (CONT'D)

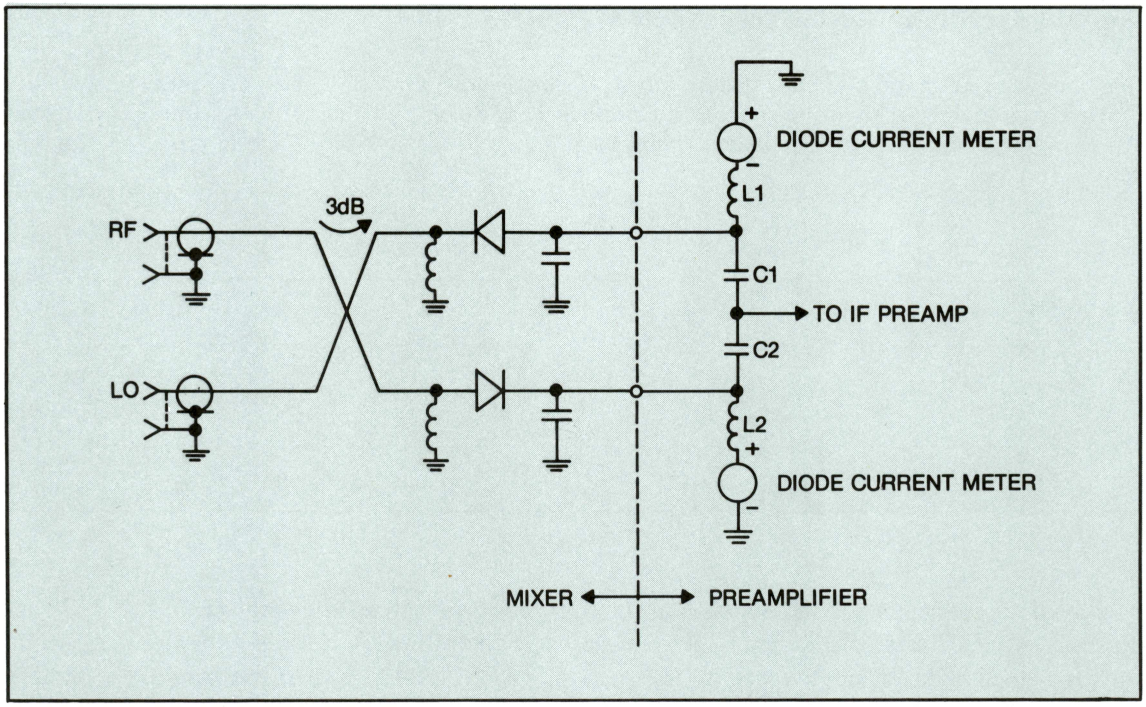


FIGURE 3

STARVED LO OPERATION

In many applications, the normal operating LO power level of +6 dBm may not be available. In such situations, you can use starved LO operation. This involves adding a small forward DC bias to each diode (+ and -), thereby forward biasing the diodes into a region which will provide sufficient conductivity modulation. Figure 4 shows typical performance for an X-band M-LINE mixer with starved LO operation at various LO power levels. As LO power is decreased, the optimum DC bias per diode also decreases. Operation at 0 dBm with proper bias yields performance very close to that obtained with a normal LO drive of +6 dBm. At −6 and −10 dBm, conversion loss increases by approximately 1.2 and 2.5 dB, respectively. You can use this technique with LO drive levels as low as −30 dBm if you can tolerate conversion loss values of approximately 25 dB. In addition to higher conversion loss, starved LO operation will penalize you in terms of intermodulation performance: specifically, third order products.

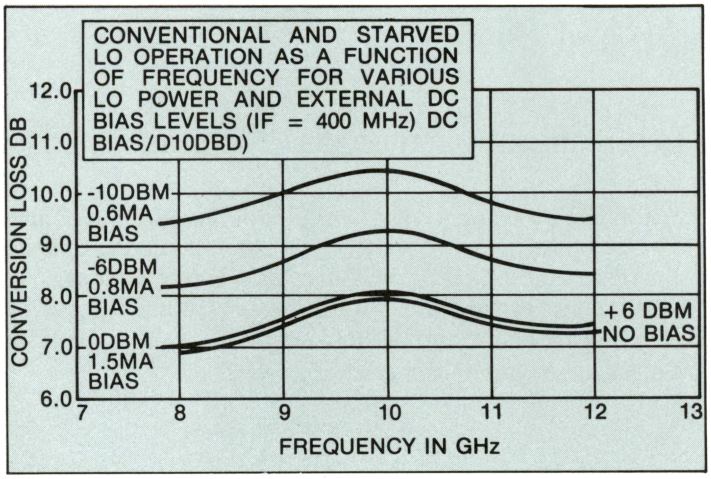


FIGURE 4

APPLICATION NOTES - COAXIAL BALANCED MIXERS (CONT'D)

INTERMODULATION CONSIDERATIONS

In wide RF bandwidth applications, intermodulation performance is of primary concern. For example, typical intermodulation characteristics for our X-band mixers are illustrated in Figures 5 and 6. Of particular interest is Figure 5, which shows the third order products generated under normal and starved LO conditions. Figure 5 is a clear illustration of the fact that best operation is realized as LO drive is increased. The improvement gained over the LO range of -10 to +10 dBm is approximately 2.5 dB intermodulation reduction for each dB of LO drive.

Figure 6 illustrates fourth and sixth order performance (2 x 2 and 3 x 3). These plots closely approximate the theoretical performance that can be expected; 2 dB and 3dB per dB input, respectively. This data was obtained under normal +6 dBm LO drive conditions. If you were to use starved LO conditions, you could expect little change in performance, as has been verified with LO levels as low as -10 dBm.

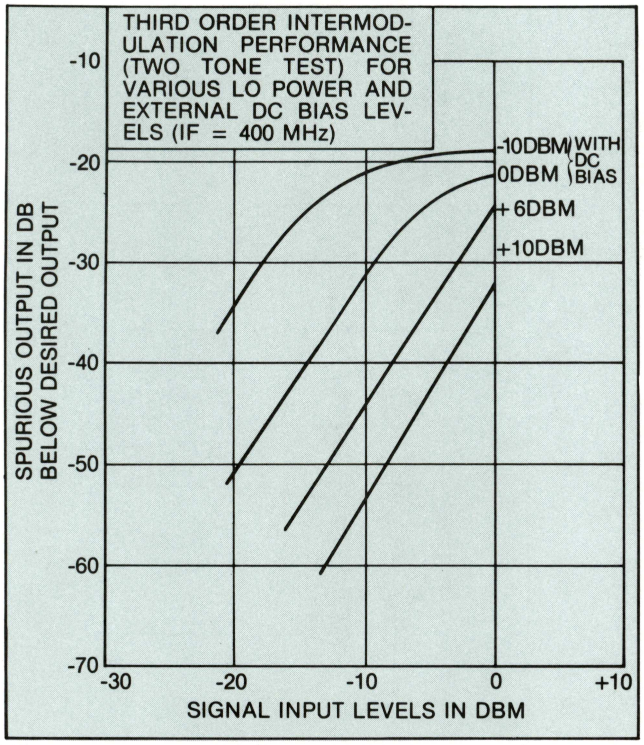


FIGURE 5

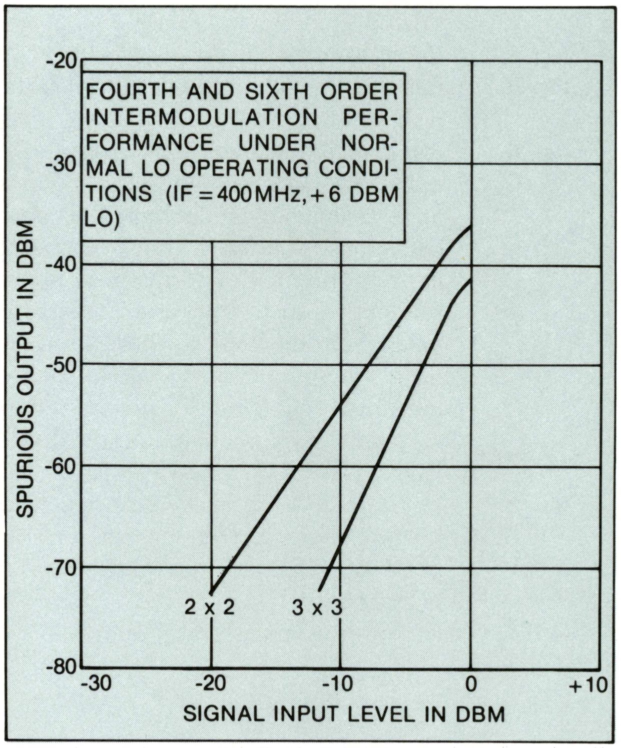


FIGURE 6

UP-CONVERTER OPERATION

For up-conversion, you must insert both diodes in the same polarity (they are in opposite polarity for normal down-conversion) and feed your signals into the IF port and one RF port. Sum and difference frequencies are then available at the remaining RF port. A DC return on the IF side is required for up-converter operation. In most cases, this can be included by Sage within the unit if required, or you can add the DC return externally in the IF input circuit. Your DC return can take the form af a shunt resonant choke or other path to ground.

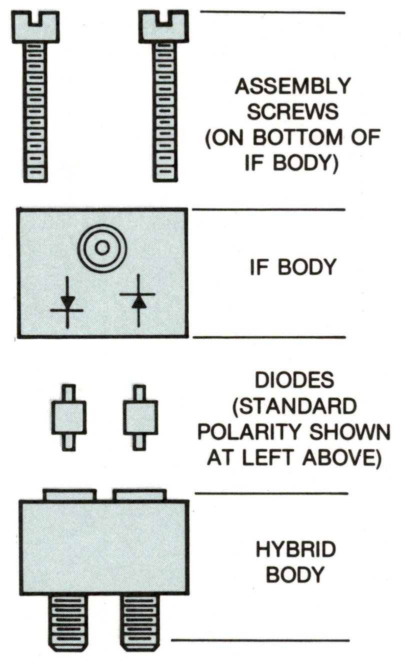
APPLICATION NOTES - COAXIAL BALANCED MIXERS (CONT'D)

Conversion loss for up-converter operation is defined as the ratio of desired output sideband power to the lowest input level signal. Excellent conversion efficiences can be obtained with input power levels up to the range of 13 to 20 dBm. We have not established specifications, however, because each application has its own unique requirements with respect to power levels, conversion loss, and other associated characteristics.

FIELD REPLACEMENT OF DIODES

Field replacement of the diodes is a simple matter, and is outlined step-by-step below.

Step 1. Hold the mixer vertical with the IF body side up.
Step 2. Remove the two assembly screws.
Step 3. Lift the IF body section to expose the diodes.
Step 4. Remove the diodes and replace as required for your desired mode of operation. Normal diode polarity for down-converter operation is shown in the diagram to the right. If you wish to operate the unit as an up-converter, reverse the polarity of one diode so that both diodes have the same polarity. (Also, observe the notes regarding DC return requirements in the preceding section on UP-CONVERTER OPERATION.)
Step 5. Insert the IF body back into position (still holding the mixer in the same vertical position, with the diodes inserted into the hybrid body).
Step 6. Replace the two assembly screws.


ASSEMBLY SCREWS (ON BOTTOM OF IF BODY)
IF BODY
DIODES (STANDARD POLARITY SHOWN AT LEFT ABOVE)
HYBRID BODY

DIODE REPLACEMENT INSTRUCTIONS

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ROTARY JOINTS

CONTENTS OF THIS SECTION PAGE

A Guide to Rotary Joint Selection **109**
Custom Engineering Capabilities **111**
Standard Products **116**
Application Notes **122**

A GUIDE TO ROTARY JOINT SELECTION

The term "rotary joint" describes a device used to transmit energy from a stationary R.F. line to a rotating R.F. line. Because a rotary joint is a dynamic component, the satisfaction of its R.F. requirements depends a great deal on the mechanical design. Classifications of rotary joints generally describe the transmission line media to be coupled, the electromagnetic mode of operation, and the mechanical location of one terminal relative to the other. Thus, there are three major classifications:

TEM Mode or Coaxial Line Type — A rotary joint which has coaxial input and output terminals, and in which the transmission path is also a coaxial line. This type operates in the TEM mode of propagation and has the broadest operating frequency bandwidth. Power handling capability generally parallels that of the mating connectors.

TE_{10} to TEM to TE_{10} Mode or Waveguide to Coaxial Transition Type — A rotary joint which has rectangular waveguide input and output terminals, and in which the transmission path is a coaxial line connecting the two waveguides. This type can be considered to operate in the TE_{10} mode of propagation, in the waveguide section, but it must transduce to the TEM in the coaxial portion. Bandwidth is limited by the usable bandwidth of the waveguide size. Power handling capability is limited by the coaxial section.

TE_{10} to TM_{01} to TE_{10} Mode or Rectangular to Circular Waveguide Transition Type — A rotary joint which has rectangular waveguide input and output terminals and in which the transmission path is a circular waveguide connecting the two rectangular waveguides. This type operates in the TE_{10} mode of propagation in the rectangular waveguides and transduces to the TM_{01} mode in the circular waveguide. The usable bandwidth for this type is about 6%, but it has the highest power handling capability of all types discussed.

There are also three subclassifications which are defined by the physical geometry of the rotary joint.

L Type — One terminal is perpendicular to the axis of rotation
I Type — Both terminals are co-linear with the axis of rotation
U Type — Both terminals are perpendicular to the axis of rotation

The contacting junctions incorporated in the broadband coaxial units described on the following pages are fabricated from a combination of precious metals. One contact is fabricated from coin silver; the other from a combination of porous carbon impregnated with pure silver. These form a continuously contacting thrust surface. Spring loading is used to ensure continuous contact.

Another common coupling method employed by Sage in the design of waveguide rotary joints is the noncontacting choke coupling. Our standard designs incorporate a folded half-wave section terminated in a short circuit. Each half-wave section consists of 2 quarter-wave sections, one of which has several times the impedance of the other. This greatly reduces the frequency sensitivity of the choke. Well-made junctions of this type have almost unmeasurable reflections over as much as a 30 per cent band.

One advantage of the simple coaxial line structure is that is can serve as the basic building block for any number of line transitions. Various input and output combinations give the finished rotary joint many physical configurations. Two typical styles are shown in the photos on this page.

An additional advantage of the coaxial rotating structure is the manner in which several coaxial lines can be combined on the same axis to form multiple-channel units.

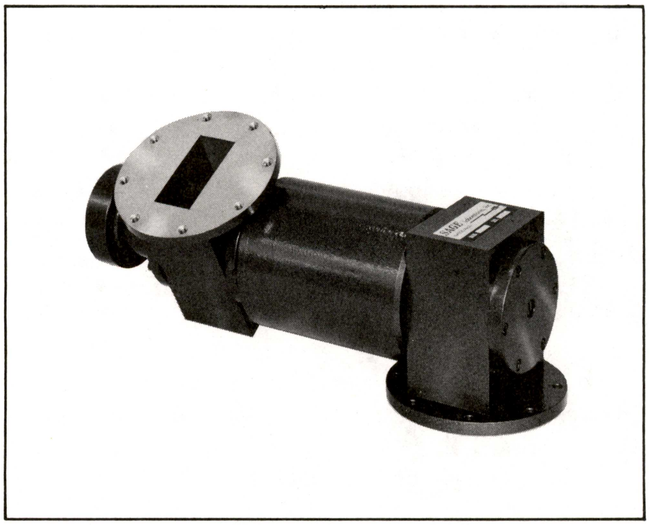
In the case of coaxial units, the choice will generally be determined by the connectors used in the system. If type N connectors are required, our Model 305 will meet most system requirements at the lowest cost. Model 344 is somewhat smaller and more expensive. (Its smaller bearings add to the cost, but permit smaller sealing rings and higher operating speeds.) The internal transmission lines are identical in Models 305 and 344.

Mounting flanges are offered as extra-cost standard features on Models 305F and 344F. You may find it less expensive to use our mounting flanges, rather than designing clamps into your system gimbal.*

Although we list only SMA, type N, 7/8", 1-5/8" and 3-1/8" units as standard catalog items, we frequently supply (as specials) coaxial rotary joints with other connector types, including HN and TNC.

If you do not see what you need among our standard models, please query us. Your inquiries will be answered promptly.

UG-39/U
SAGE
NATICK, MASS.
MOD.



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*In no case should our standard catalog rotary joints be expected to support other structures; however, we should be happy to quote on special units with heavier bearings capable of withstanding antenna axial and thrust loads.

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CUSTOM ENGINEERING CAPABILITIES IN ROTARY JOINTS

GENERAL

Sage Laboratories Inc. has supplied custom-engineered rotary joints ranging in complexity from our compact, low cost model FRJ-1896 (surface-to-air missile application) to a highly complex PTA & Roll assembly for the F-111.

Your engineering inquiries are cordially invited. In order to expedite our response to your inquiries, we suggest that the following parameters be specified.

ELECTRICAL (EACH CHANNEL)

- frequency range
- VSWR
- insertion loss
- peak and average power
- interchannel isolation (if unit is multi-channel)

MECHANICAL

- connectors
- I, L or U configurations
- envelope restrictions
- torque limitations
- rotational speed

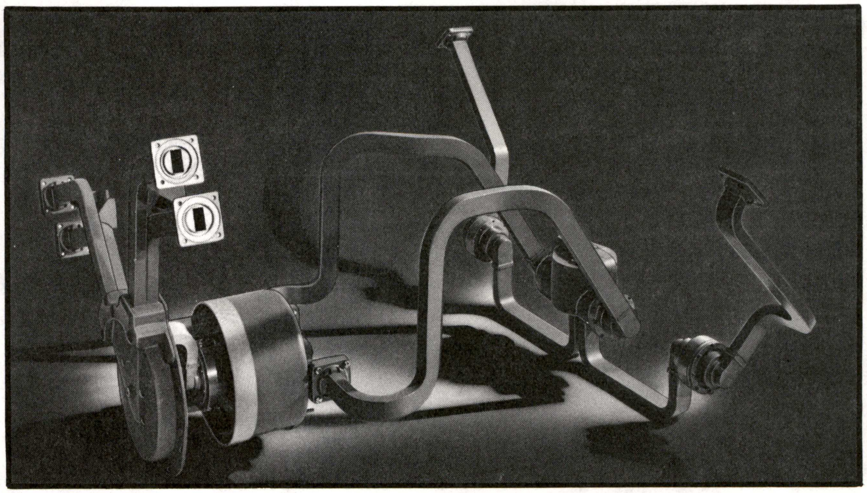
ENVIRONMENTAL

- external environment
- internal environment (gas type and pressure)
- temperature range

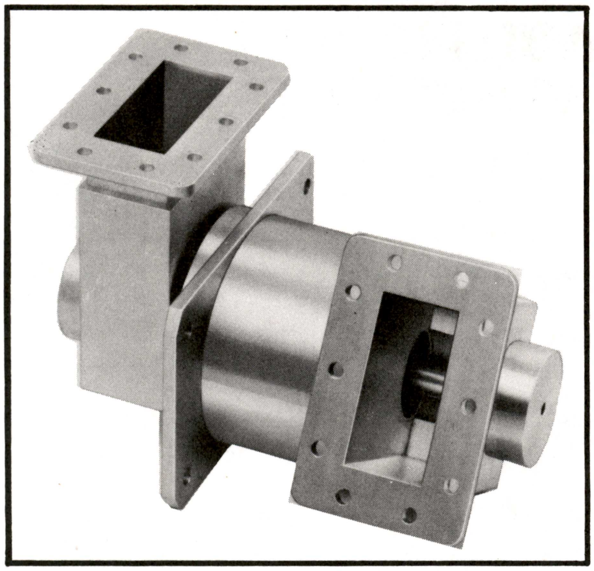
Also supply any other known critical system requirements which might affect rotary joint performance or packaging.

WE HAVE SUPPLIED OVER 1000 OF THESE F-111 PTA & ROLL ASSEMBLIES

This Ku-band assembly includes cascaded TM_{01} mode rotary joints and step-type TE_{10} swivel joints. The unit operates over a 4% bandwidth at full waveguide power. VSWR is held to less than 1.17:1 for all joint positions. Sage has shipped more than 1000 of these production units.



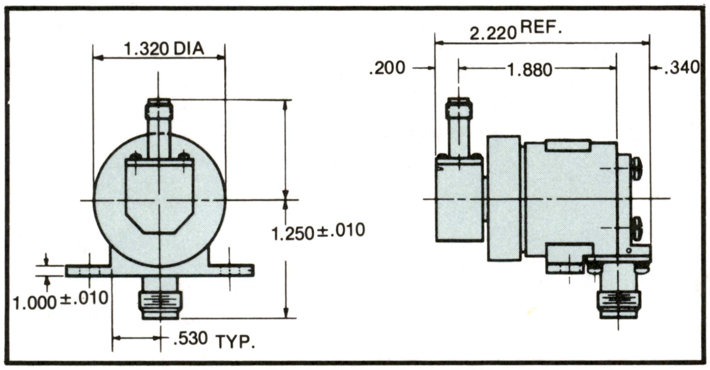
CUSTOM ENGINEERING CAPABILITIES IN ROTARY JOINTS (Continued)



AN AWACS PROGRAM OFFSHOOT, THIS COMPACT S-BAND UNIT HANDLES 5 MEGAWATTS PEAK POWER

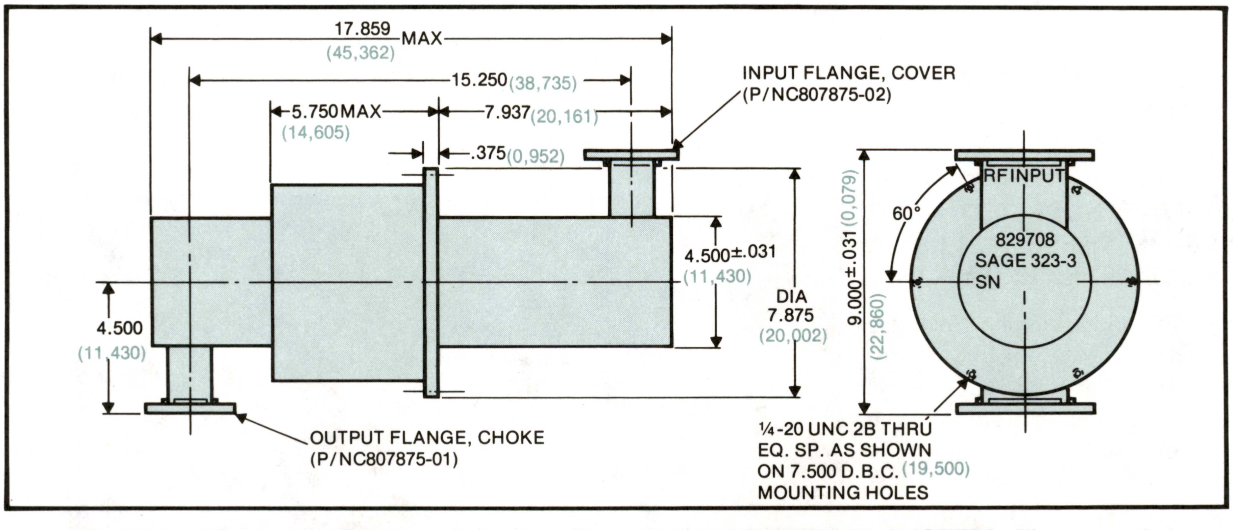
This descendant of the AWACS Program is a compact TEM mode S-band rotary joint which will operate at 10 KW average power and 5 megawatts peak power. VSWR is less than 1.15:1 over the 20% bandwidth from 2900-3500 MHz. Non-contacting choke joints and aluminum construction hold the weight to only 8 pounds. The overall length of the unit is 9 inches (22,860 cm). The model number is FRJ-1840.

MODEL FRJ-1840 SHOWN 1/3 ACTUAL SIZE


1.320 DIA
1.250±.010
1.000±.010
.530 TYP.
2.220 REF.
.200
1.880
.340

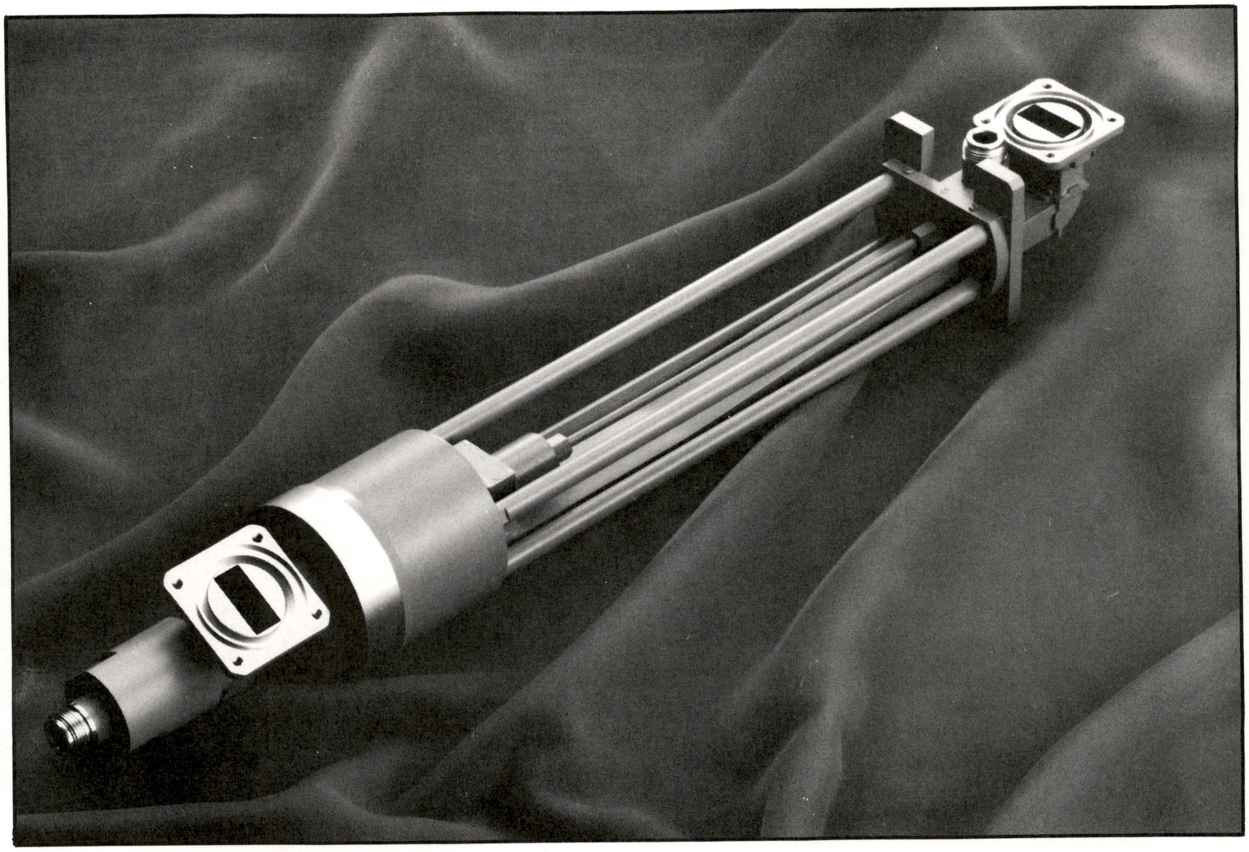
THIS IS OUR FRJ-1007 DESIGN, A HIGH RELIABILITY SPACE-QUALIFIED UNIT

Model FRJ-1007 was designed to meet severe interface constraints. It utilizes non-contacting choke coupling, and operates over the standard communications band from 1.7-2.4 GHz. The starting torque of the unit is less than 10 ounce-inches.


17.859 MAX (45,362)
15.250 (38,735)
5.750 MAX (14,605)
7.937 (20,161)
.375 (0,952)
INPUT FLANGE, COVER (P/NC807875-02)
4.500±.031 (11,430)
DIA 7.875 (20,002)
9.000±.031 (22,860) (0,079)
4.500 (11,430)
60°
RF INPUT
829708
SAGE 323-3
SN
OUTPUT FLANGE, CHOKE (P/NC807875-01)
¼-20 UNC 2B THRU
EQ. SP. AS SHOWN
ON 7.500 D.B.C. (19,500)
MOUNTING HOLES

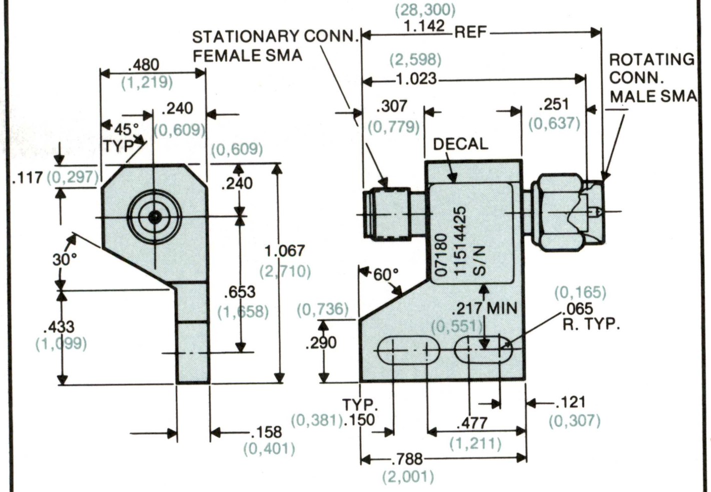
MODEL 323-P3 WAS DEVELOPED FOR A CANCER TREATMENT SYSTEM. This special design connects the output of a high power klystron to a linear accelerator used for cancer treatment via high energy X-rays. TE_{10} mode circular guide is used to provide reliable high power operation, limited only by the mating rectangular waveguide. Operating power is 21 KW average; 25 Megawatts peak. Snap rings simplify the maintenance of O-rings and bearing lubricants.

CUSTOM ENGINEERING CAPABILITIES IN ROTARY JOINTS (Continued)



MODEL FRJ-2095 WAS DEVELOPED TO MEET NEEDS OF A PERISCOPE APPLICATION

This dual-channel design features an X-band waveguide channel and an L-band coaxial channel. The unit was designed to fit into a slip-ring assembly inside a submarine periscope.

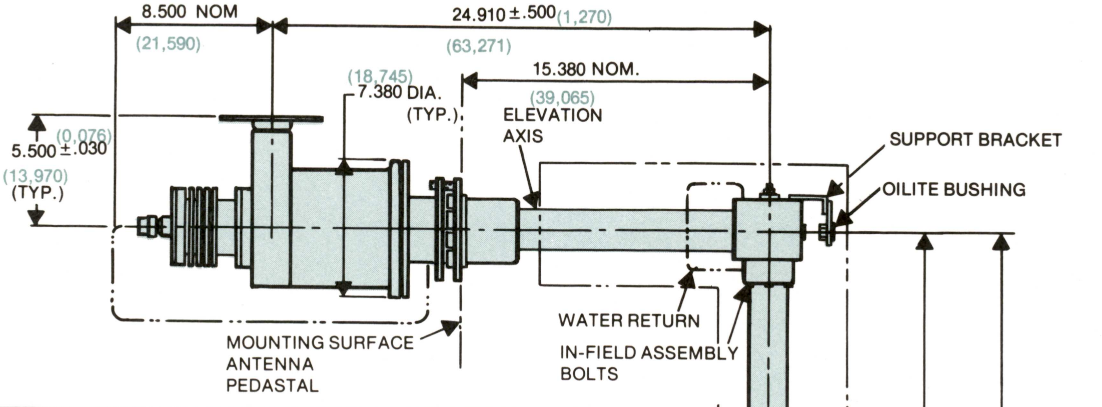

STATIONARY CONN.
FEMALE SMA
(28,300)
1.142 REF
(2,598)
1.023
ROTATING
CONN.
MALE SMA
.480
(1,219)
.240
(0,609)
45°
TYP
(0,609)
.117 (0,297)
.240
.307
(0,779)
.251
(0,637)
DECAL
07180
11514425
S/N
1.067
(2,710)
30°
.653
(1,658)
60°
(0,736)
.217 MIN
(0,551)
(0,165)
.065
R. TYP.
.433
(1,099)
.290
TYP.
(0,381).150
.477
(1,211)
.121
(0,307)
.158
(0,401)
.788
(2,001)

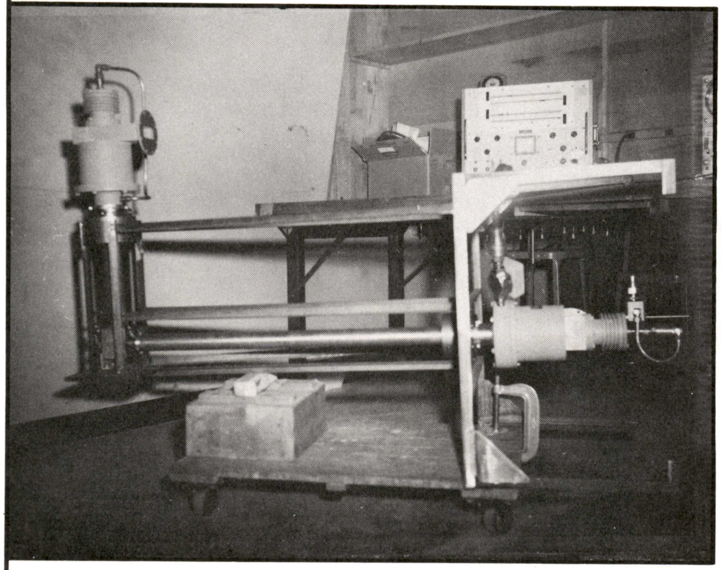
MODEL FRJ-1896 WAS PRODUCED IN HIGH VOLUME AT LOW COST FOR A NATO STANDARD SURFACE-TO-AIR MISSILE APPLICATION

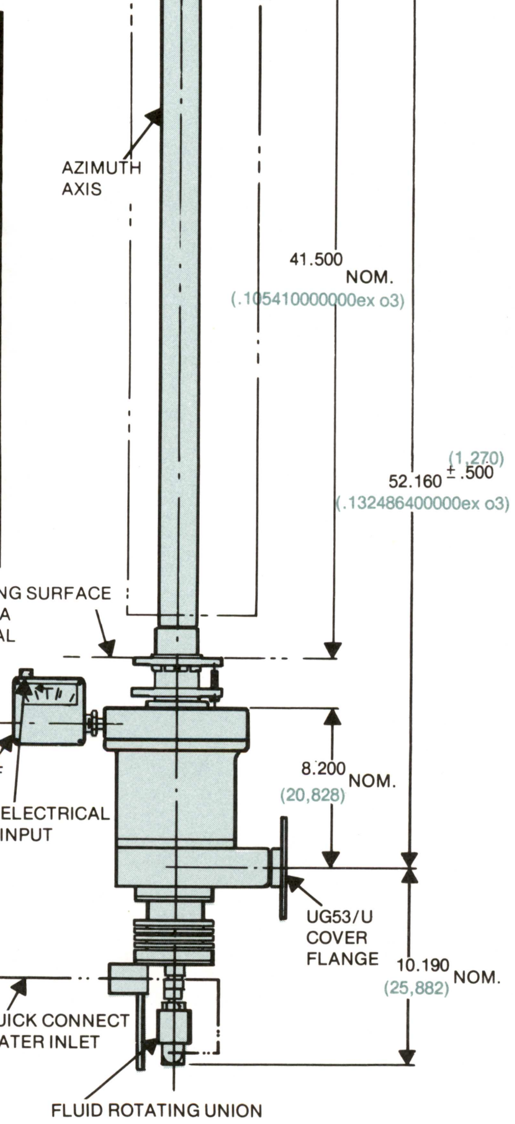
The objective here was low cost, reliable performance to meet a predetermined interface and electrical specification.

All program objectives were met.

CUSTOM ENGINEERING CAPABILITIES IN ROTARY JOINTS (Continued)


8.500 NOM
(21,590)
24.910 ±.500 (1,270)
(63,271)
15.380 NOM.
(39,065)
(18,745)
7.380 DIA.
(TYP.)
ELEVATION
AXIS
5.500 ±.030 (0,076)
(13,970)
(TYP.)
SUPPORT BRACKET
OILITE BUSHING
WATER RETURN
IN-FIELD ASSEMBLY
BOLTS
MOUNTING SURFACE
ANTENNA
PEDASTAL



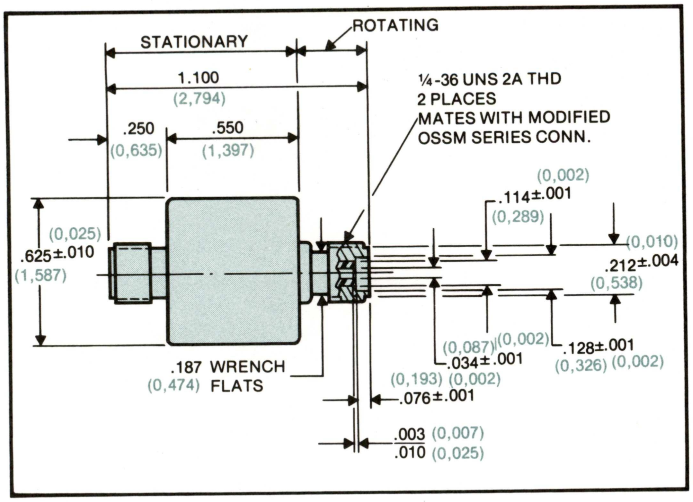

AZIMUTH
AXIS
41.500
NOM.
(.105410000000ex o3)
52.160 ±.500 (1,270)
(.132486400000ex o3)
MOUNTING SURFACE
ANTENNA
PEDASTAL
QUICK CONNECT
WATER OUTLET
FLOW
INDICATOR &
SAFETY SHUT-OFF
ELECTRICAL
INPUT
8.200 NOM.
(20,828)
UG53/U
COVER
FLANGE
10.190 NOM.
(25,882)
QUICK CONNECT
WATER INLET
FLUID ROTATING UNION

MODEL 366 HANDLES 100KW AVERAGE

This S-band assembly includes cascaded azimuth and elevation rotary joints. The unit had to be designed to retrofit an existing pedestal, which ruled out the use of TE_{10} circular mode sections.

The 100 KW average power handling requirement was met by using direct liquid-cooled TEM transmission lines. The coolant is water and Glycol.

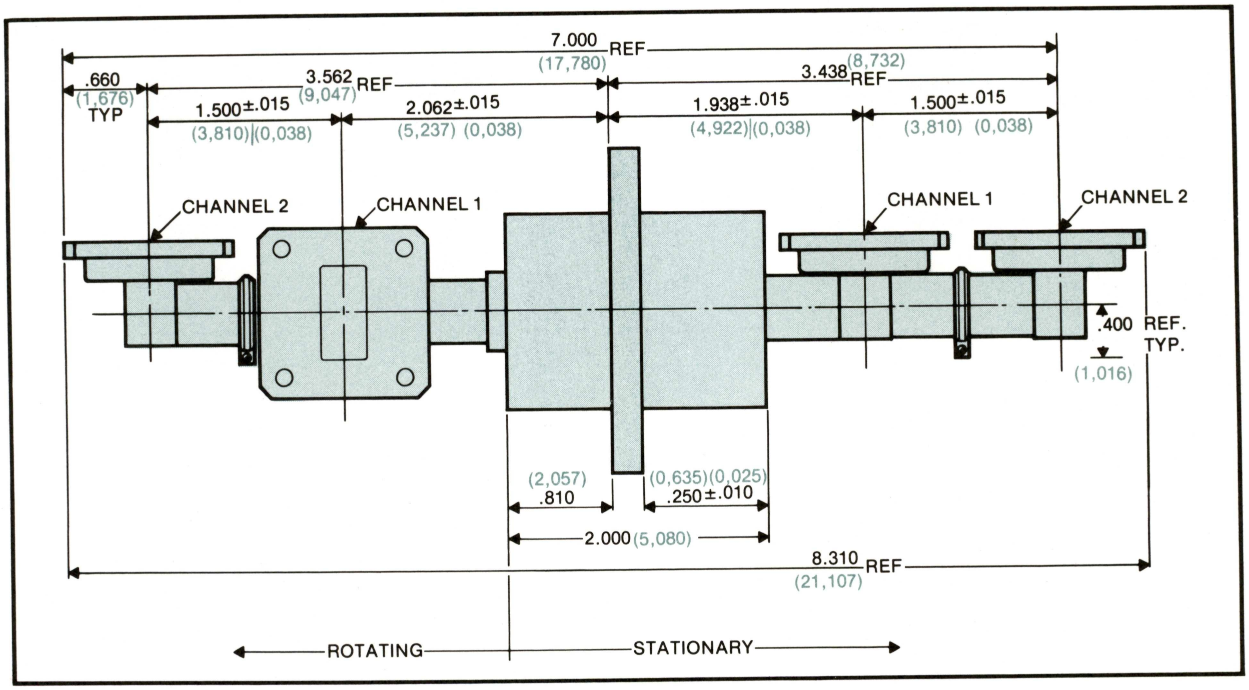
CUSTOM ENGINEERING CAPABILITIES IN ROTARY JOINTS (Continued)



STATIONARY
ROTATING
1.100 (2,794)
.250 (0,635)
.550 (1,397)
¼-36 UNS 2A THD
2 PLACES
MATES WITH MODIFIED
OSSM SERIES CONN.
(0,002) .114±.001 (0,289)
(0,025) .625±.010 (1,587)
(0,010) .212±.004 (0,538)
(0,087) (0,002) .034±.001
.128±.001 (0,326) (0,002)
.187 WRENCH FLATS (0,474)
(0,193) (0,002) .076±.001
.003 (0,007)
.010 (0,025)

MODEL FRJ-1900 WAS DESIGNED TO WITHSTAND THE RIGORS OF SUBMARINE-TOWED DEEP IMMERSION

This unit combines several unique attributes. It must provide a starting torque of less than 2 ounce-inches, and must withstand a 100-pound axial load on the connector. The unit must withstand salt water immersion to 230 feet. (Low corrosion "Illium" alloys were used.) Model FRJ-1900 can operate at 50 watts CW.



7.000 (17,780) REF
.660 (1,676) TYP
3.562 (9,047) REF
3.438 (8,732) REF
1.500±.015 (3,810) (0,038)
2.062±.015 (5,237) (0,038)
1.938±.015 (4,922) (0,038)
1.500±.015 (3,810) (0,038)
CHANNEL 2
CHANNEL 1
CHANNEL 1
CHANNEL 2
.400 REF. TYP. (1,016)
(2,057) .810
(0,635) (0,025) .250±.010
2.000 (5,080)
8.310 (21,107) REF
ROTATING
STATIONARY

MODEL FRJ-2211 IS A SPECIAL DUAL WAVEGUIDE DESIGN

This dual channel 15.8-17.2 GHz unit uses TEM mode sections between waveguide-to-TEM mode transitions. As with the other Sage units shown in this section, this unit was custom-designed to meet particular customer requirements.

sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

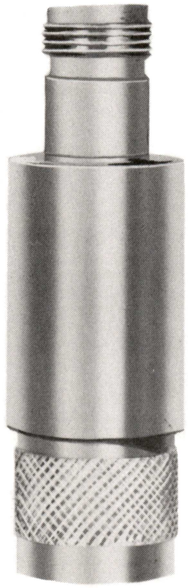
CONTACTING JUNCTION COAXIAL (TYPE N CONNECTORS) ROTARY JOINTS (MODELS 305W & 344)

FEATURES

- low cost
- compact
- DC-12.4 GHz frequency range
- weatherized for operation under environmental extremes
- proprietary precious metal contacting junctions
- high speed operation
- long life
- designed for MIL-E-5400 Class II
- usable to 18 GHz (test data supplied on special order.)

SAGE LABORATO
NATICK, MASSACH
MOD.
SER.

MODEL 305W

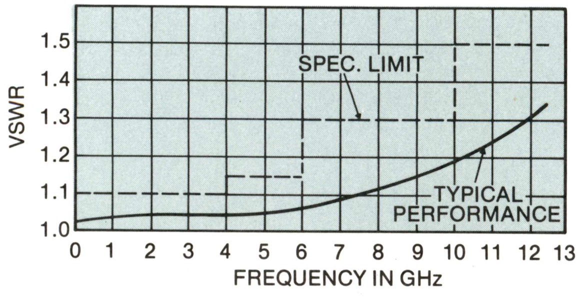


MODEL 344

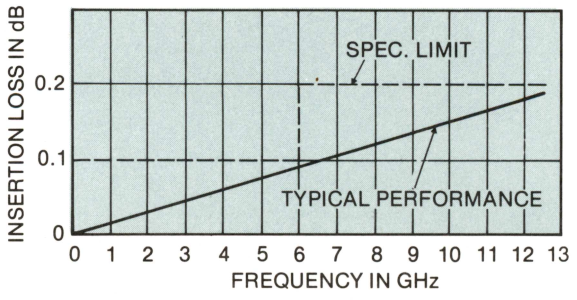
ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FREQUENCY RANGE	CONNECTOR TYPE	MAXIMUM VSWR	MAXIMUM INSERTION LOSS	ROTATIONAL EFFECT VSWR MAX. / VSWR MIN.	PEAK POWER	AVERAGE POWER (@1 GHz)
305W 305WF (flanged) 344 344F (flanged)	DC-12.4 GHz	N	1.10 DC-4 GHz 1.15 4-6 GHz 1.30 6-10 GHz 1.50 10-12.4 GHz	0.1 dB DC-6 GHz 0.2 dB 6-12.4 GHz	1.01 MAX./360°	10 KW	500 W

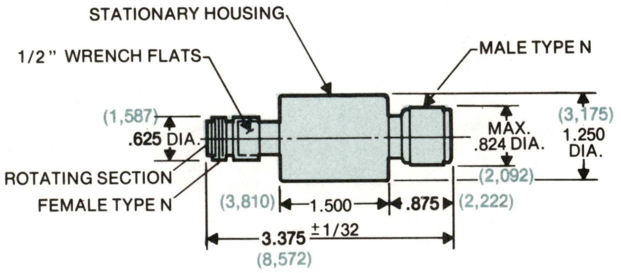
VSWR



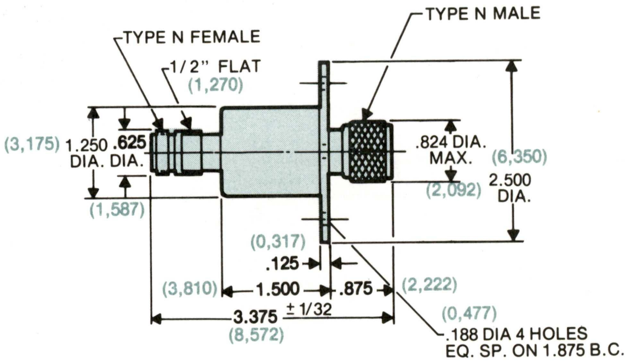
INSERTION LOSS



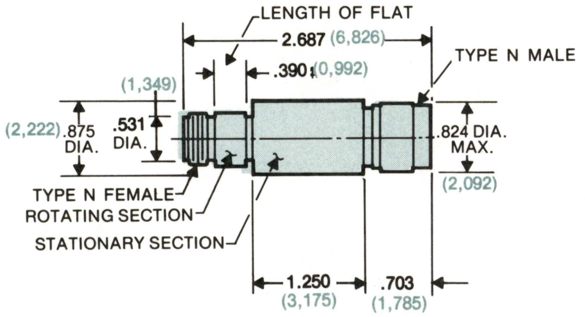
MECHANICAL DATA - MODELS 305W & 344


STATIONARY HOUSING
1/2" WRENCH FLATS
MALE TYPE N
(1,587)
.625 DIA.
MAX.
.824 DIA.
(3,175)
1.250
DIA.
ROTATING SECTION
FEMALE TYPE N
(2,092)
(3,810)
1.500
.875
(2,222)
3.375 ±1/32
(8,572)

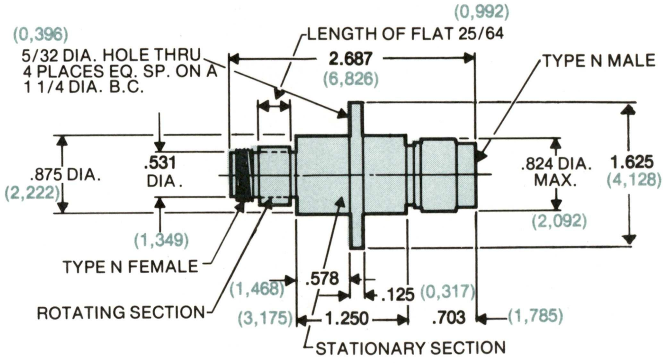
MODEL 305W


TYPE N MALE
TYPE N FEMALE
1/2" FLAT
(1,270)
(3,175) 1.250
DIA.
.625
DIA.
.824 DIA.
MAX.
(6,350)
(2,092)
2.500
DIA.
(1,587)
(0,317)
.125
(3,810)
1.500
.875
(2,222)
3.375 ±1/32
(8,572)
(0,477)
.188 DIA 4 HOLES
EQ. SP. ON 1.875 B.C.

MODEL 305WF


LENGTH OF FLAT
2.687 (6,826)
TYPE N MALE
.390 (0,992)
(1,349)
(2,222) .875
DIA.
.531
DIA.
.824 DIA.
MAX.
(2,092)
TYPE N FEMALE
ROTATING SECTION
STATIONARY SECTION
1.250
(3,175)
.703
(1,785)

MODEL 344


(0,992)
(0,396)
5/32 DIA. HOLE THRU
4 PLACES EQ. SP. ON A
1 1/4 DIA. B.C.
LENGTH OF FLAT 25/64
2.687
(6,826)
TYPE N MALE
.875 DIA.
(2,222)
.531
DIA.
.824 DIA.
MAX.
1.625
(4,128)
(2,092)
(1,349)
TYPE N FEMALE
.578
(1,468)
.125 (0,317)
ROTATING SECTION
(3,175)
1.250
.703
(1,785)
STATIONARY SECTION

MODEL 344F

MODEL NUMBER	CONNECTOR TYPE	NOMINAL STARTING TORQUE	CONTINUOUS ROTATIONAL SPEED	MINIMUM ENVIRONMENTAL SPECIFICATION	APPROXIMATE WEIGHT
305W	N	8 oz-in	500 rpm	MIL-E-5400 CL II	8 oz
305WF	N	8 oz-in	500 rpm	MIL-E-5400 CL II	9 oz
344	N	7 oz-in	1500 rpm	MIL-E-5400 CL II	4 oz
344F	N	7 oz-in	1500 rpm	MIL-E-5400 CL II	5 oz

MATERIALS & FINISHES

Fabricated in brass
Beryllium copper connector contacts
Proprietary precious metal inner & outer contact junctions

All metals except contact-junctions silver-plated & rhodium-flashed
All materials & finishes to MIL Specs

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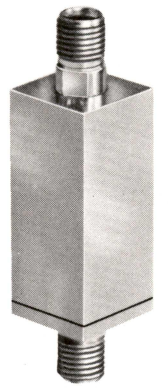
CONTACTING JUNCTION MINIATURE COAXIAL (SMA CONNECTORS) ROTARY JOINTS (MODEL 345)

FEATURES

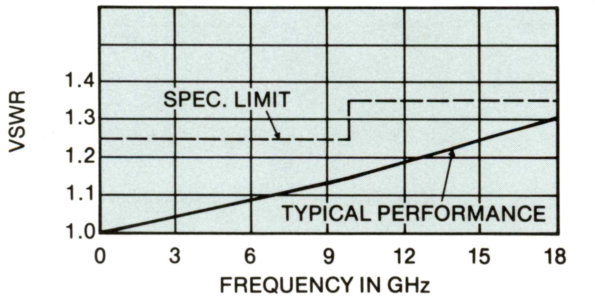
- DC-18 GHz frequency range
- light weight
- square cross-section for easy mounting
- proprietary precious metal contacts for low noise operation
- weatherized version (Model 345W) available



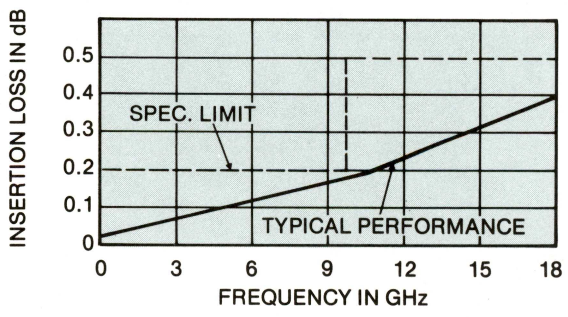
ELECTRICAL SPECIFICATIONS

Model Number	345	(Weatherized Version 345W)
Frequency Range		DC-18 GHz
Connector Type		Female SMA
Maximum VSWR	1.25	DC-10.0 GHz
	1.35	10.0-18.0 GHz
Insertion Loss	<0.2 dB	DC-10.0 GHz
	<0.5 dB	10.0-18.0 GHz
Rotational Effect	(Max. VSWR/Min. VSWR)	1.02 Max./360°
Average Power at 1 GHz		100 Watts

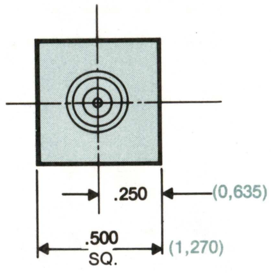
VSWR

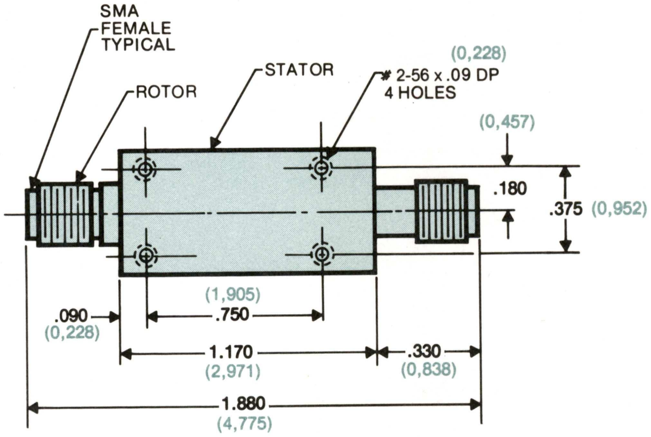


INSERTION LOSS



MECHANICAL DATA - MODEL 345


.250
(0,635)
.500
SQ.
(1,270)


SMA
FEMALE
TYPICAL
ROTOR
STATOR
(0,228)
# 2-56 x .09 DP
4 HOLES
(0,457)
.180
.375 (0,952)
(1,905)
.750
.090
(0,228)
1.170
(2,971)
.330
(0,838)
1.880
(4,775)

Model Number		345
Maximum Starting Torque	345	1.5 oz-in
(weatherized version)	345W	3.0 oz-in
Continous Rotational Speed		100 rpm
Intermittent Rotational Speed		175 rpm
Connector Type		SMA Female
Weight		1.2 oz

MATERIALS & FINISHES

Fabricated in brass
Beryllium copper connector contacts
Proprietary precious metal inner & outer contacting junctions.

All metals except contacting junctions silver-plated & gold-flashed
All materials & finishes to MIL specs

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CONTACTING JUNCTION COAXIAL 7/8", 1-5/8" & 3-1/8" EIA ROTARY JOINTS (MODELS 330, 334, 343A & 343F)

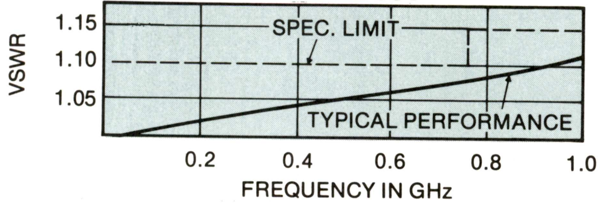
FEATURES

- 3-1/8", 1-5/8", and 7/8" EIA transmission lines
- heavy duty long-life bearings
- proprietary precious metal contacts
- low noise
- weather and pressure sealed
- meet MIL-E-5400 Class II

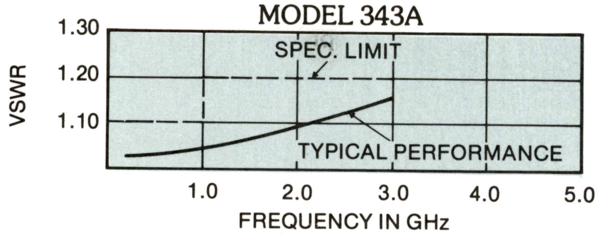
ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FREQUENCY RANGE	CONNECTOR TYPE	MAXIMUM VSWR	MAXIMUM INSERTION LOSS	ROTATIONAL EFFECT $\frac{\text{MAX. VSWR}}{\text{MIN. VSWR}}$	PEAK POWER	AVERAGE POWER (@1 GHz)
334	DC-1.0 GHz	3-1/8" EIA	1.10 DC-750 MHz 1.15 .75-1.0 GHz	0.05 dB	1.01 max./360°	1 MW	15 KW
330	DC-2.0 GHz	1-5/8" EIA	1.20 DC-2.0 GHz	0.1 dB	1.01 max./360°	300 KW	5 KW
343A	DC-3.0 GHz	7/8" EIA	1.10 DC-1 GHz 1.20 1-3 GHz	0.1 dB	1.01 max./360°	150 KW	2 KW
343F	DC-5 GHz	7/8" EIA	1.10 DC-1 GHz 1.25 1-5 GHz	0.1 dB	1.01 max./360°	150 KW	2 KW

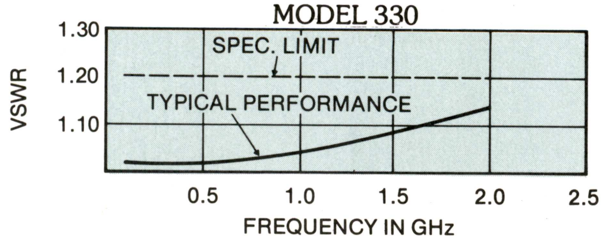
MODEL 334



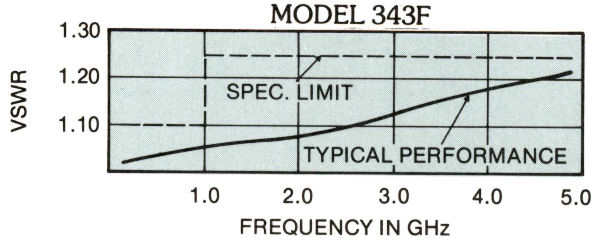
MODEL 343A



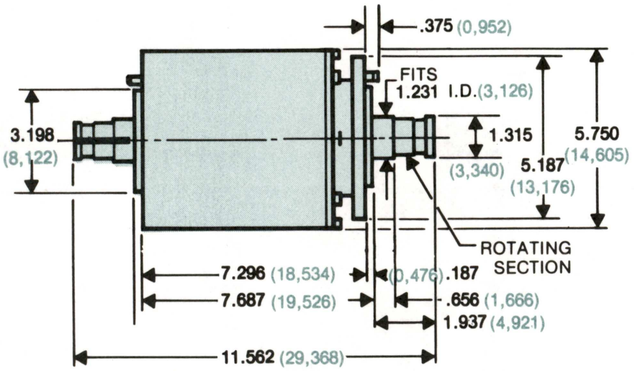
MODEL 330



MODEL 343F

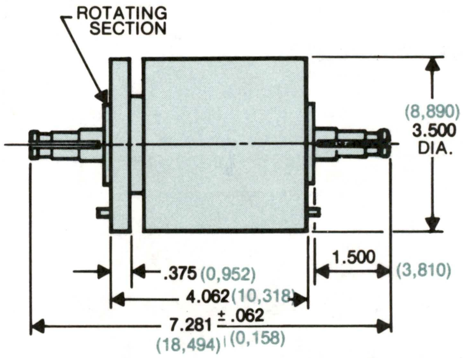


MECHANICAL DATA - MODELS 330, 334, 343A & 343F



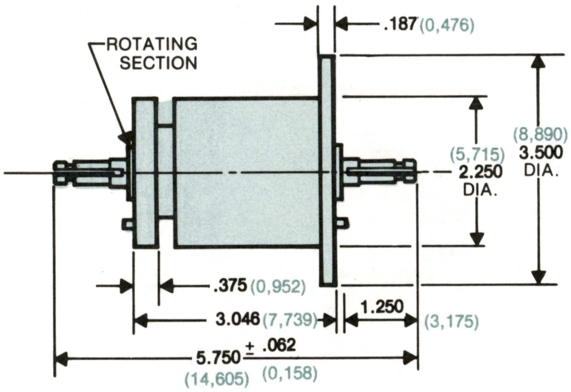
.375 (0,952)
FITS
1.231 I.D. (3,126)
3.198
(8,122)
1.315
(3,340)
5.187
(13,176)
5.750
(14,605)
ROTATING
SECTION
7.296 (18,534)
(0,476) .187
7.687 (19,526)
.656 (1,666)
1.937 (4,921)
11.562 (29,368)

MODEL 334



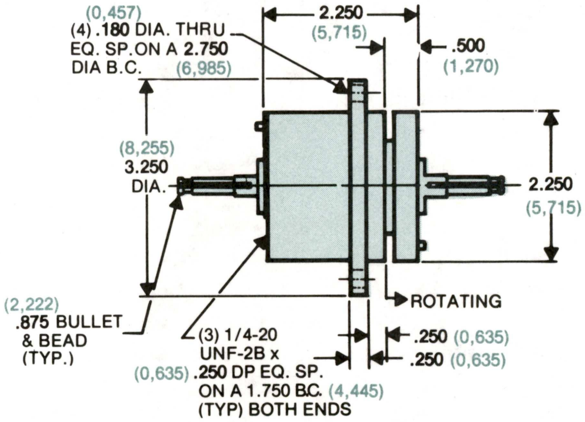
ROTATING
SECTION
(8,890)
3.500
DIA.
.375 (0,952)
1.500
(3,810)
4.062 (10,318)
7.281 ± .062
(18,494) (0,158)

MODEL 330



ROTATING
SECTION
.187 (0,476)
(8,890)
3.500
DIA.
(5,715)
2.250
DIA.
.375 (0,952)
3.046 (7,739)
1.250
(3,175)
5.750 ± .062
(14,605) (0,158)

MODEL 343A



(0,457)
(4) .180 DIA. THRU
EQ. SP. ON A 2.750
DIA B.C. (6,985)
2.250
(5,715)
.500
(1,270)
(8,255)
3.250
DIA.
2.250
(5,715)
ROTATING
(2,222)
.875 BULLET
& BEAD
(TYP.)
(3) 1/4-20
UNF-2B x
(0,635) .250 DP EQ. SP.
ON A 1.750 B.C. (4,445)
(TYP) BOTH ENDS
.250 (0,635)
.250 (0,635)

MODEL 343F

MODEL NUMBER	CONNECTOR TYPE	NOMINAL STARTING TORQUE	CONTINUOUS ROTATIONAL SPEED	MINIMUM ENVIRONMENTAL SPECS	APPROXIMATE WEIGHT
334*	3-1/8" EIA	35 oz-in	100 rpm	MIL-E-5400 CL II	7 lb
330*	1-5/8" EIA	15 oz-in	300 rpm	MIL-E-5400 CL II	4.5 lb
343A*	7/8" EIA	15 oz-in	500 rpm	MIL-E-5400 CL II	3 lb
343F*	7/8" EIA	15 oz-in	500 rpm	MIL-E-5400 CL II	2 lb

* Weatherized and pressurized to 30 psig

MATERIALS & FINISHES

Fabricated in brass or aluminum
Beryllium copper connector contacts
Proprietary precious metal inner & outer contact-junctions

All metals except contact-junctions silver-plated & rhodium-flashed (343F aluminum body irridite finish)
All materials & finishes to MIL specs

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APPLICATION NOTES ROTARY JOINTS

POWER HANDLING CONSIDERATIONS

As demonstrated by the Model 323P3 rotary joint (see Custom Engineering Capabilities, this product section), circular waveguide mode rotary joints can handle very high power levels. In cases where size or bandwidth requirements negate this approach, the peak power handling capabilities of standard rotary joints can be increased by pressurizing the transmission line. The use of SF6 or Freon in the pressurized lines provides a further increase in power handling. Conversely, if the system is not pressurized, peak power must be derated with altitude in accordance with standard scales.

If you plan to pressurize your rotary joints, you must consider two factors relating to rotating seals. The first factor is *compatibility with fluids or gases* which may be present. This is a matter which should be discussed with the factory before you place your order. Such early discussions will avoid many problems.

The second factor is *leak rate vs. temperature*. This is a critical factor if you anticipate operating at temperatures below −40°C. None of the standard simple seals using elastomer O-rings, quad-rings, or metal-spring-backed Teflon O-rings can provide reliable leak-free dynamic seals below −40°C. If you require a very low leak rate at such low temperatures, you should consider the use of face seals or fluidmagnetic seals. The drawbacks of the latter seals are higher cost, size, and weight. In most systems, it is better to tolerate a higher leak rate if the duration of such low temperature conditions is comparatively brief. However, Sage Laboratories will be happy to meet whatever requirements you deem necessary.

Average power should be derated from full power at 25°C to zero at 125°C. Average power should also be derated by a factor of $1/\sqrt{\text{frequency}}$.

The average power handling capability of standard rotary joints can be increased substantially over the ratings given in the product data pages. Some of the techniques used by Sage engineers to meet special higher power requirements include the use of dielectric supports having higher thermal conductivity, center conductor stub supports which provide a direct metallic thermal path, and various forms of liquid cooling. As an example of the latter approach, we have shipped S-band rotary joints which handled 100 KW average through a coaxial assembly.

ROTARY JOINT LIFE

Among the standard rotary joints described in this product section of the catalog, life expectancy is a function of wear at three major points ... *bearings, seals,* and *contacting junctions*. (Non-contacting choke joints are used in some special designs, thus eliminating one of the three major wear points. As might be expected, there are trade-offs; limited bandwidth and lack of DC transmission.

Bearing life is affected by travel, mechanical loading, and corrosion. During factory assembly, we use a light preload and grease. The grease provides limited corrosion protection and lubrication. Generally speaking, with no external loading, bearing life should be measured in years (10^9 revolutions). Rotational speed, however, plays a major part in determining wear-related life expectancy. External mechanical loading, including vibration-induced loads, can also shorten life.

If your operational conditions are clearly specified in early discussions with Sage engineers, steps can be taken to maximize life for your particular application. Sage has delivered custom designed units which accomodate high axial forces (e.g., an ocean-towed antenna application) and external loading (e.g., a rotary joint which supports an antenna and accomodates the transverse forces of a belt servo drive). Some of our custom designed rotary joints use plastic bearings which require neither lubrication nor corrosion protection. In some cases, we have designed rotary joints without bearings for mounting in the system pedestals.

As previously noted, O-ring *seals* are commonly used in our standard rotary joints. If the units are operated at moderate speeds and temperatures, these seals will provide long life (typically 10^6 revolutions in the case of small rotary joints ... less in units requiring large diameter seals). In cases where periodic field replacement of the seals is considered advisable, we can supply rotary joints which facilitate such maintenance. Alternatively, we can supply units having extended-life face seals or fluidmagnetic seals.

The *contacting junctions* manufactured by Sage are fabricated from silver-impregnated graphite and coin silver.* These junctions are self-lubricating. Spring preloads and slide fingers permit take-up of wear. The useful life of the units terminates when wear-particles coat the dielectric surfaces. With the low pressures applied to the mating surfaces, this coating is a slow process. The total number of revolutions is the key factor. 10^8 revolutions is a conservative number for junction-related life expectancy.

SONAR APPLICATIONS

Some of our customers have measured video noise levels in our rotary joints, and have found the noise levels to be excellent. As a result, Sage rotary joints are being used in sonar cable reels.

One typical application of our Models 305 and 344 met the following low frequency noise specification limits:

"After 250,000 revolutions at speeds up to 50 rpm, with a DC current of 1 mA, the noise (E noise) in a 1-Hz bandwidth shall not exceed:

$64.5f^{-2.15}$ microvolts from 20-170 Hz or 1 nanovolt from 170 Hz to KHz"

*Please note that our contacts do not contain mercury. Some military specifications prohibit the use of mercury.

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COAXIAL ATTENUATORS & TERMINATIONS

CONTENTS OF THIS SECTION PAGE

A Guide to Selection **124**
Standard Products **125**

A GUIDE TO SELECTION

Sage coaxial terminations are of two general types:

- those using series-lumped resistors
- those using distributed loss

The majority of the terminations listed in the following pages fall into the first category. They range from small SMA units to Model 9600, which is conservatively rated at 25 watts. For maximum operating life at up to 2.5 KW peak power, we recommend Model 9600 (to 5 GHz) over Models 9200 or 9400. Model 9600 has a larger resistor, which will suffer less stress from peak power and voltage.

The distributed loss units have a low frequency limit which is determined by available length; however, they are ideal for high power applications because the lossy coating is located directly on the outer metal walls. (See Model 9800J, which is usable to above 12 GHz.) (Type N female is the standard connector for Model 9800J, but other types can be supplied. Please contact the factory for availability.)

Attenuators. We direct your attention to our series 9990 attenuators, which offer significant power handling capability and a selection of attenuation-versus-frequency slopes. They are reasonably priced, complete with cooling fins, and for even lower cost you can procure them without cooling fins and mount them directly to your heat sink.

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MINIATURE 50-OHM ½-WATT COAXIAL TERMINATIONS

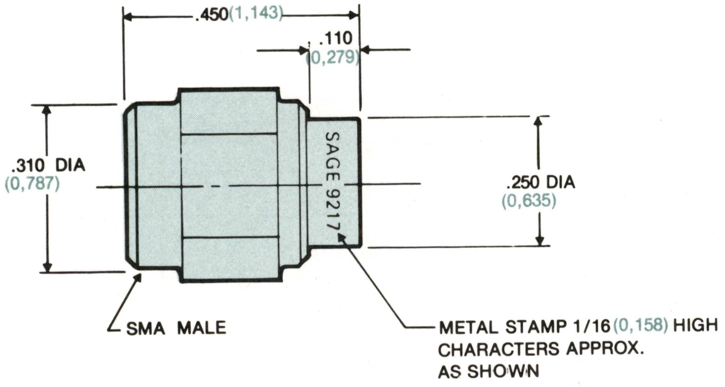
FEATURES

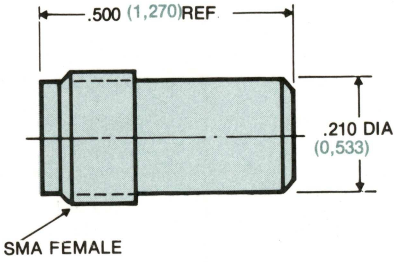
- miniature
- DC-18 GHz
- low price
- SMA connectors

MODEL 9217

MODEL 9217F

MECHANICAL DATA


.450(1,143)
.110
(0,279)
.310 DIA
(0,787)
SAGE 9217
.250 DIA
(0,635)
SMA MALE
METAL STAMP 1/16(0,158) HIGH
CHARACTERS APPROX.
AS SHOWN


.500 (1,270)REF
.210 DIA
(0,533)
SMA FEMALE

MATERIALS & FINISHES

Fabricated in passivated stainless steel
Special film-coated ceramic resistors
Beryllium copper contacts

All SAGELINE materials & finishes to Government specs
Alternative materials & finishes on special order

MODEL NUMBER	MAXIMUM VSWR	CONNECTOR TYPE	DIMENSIONS				WEIGHT
			DIAMETER		LENGTH		
			in.	cm	in.	cm	
9217	1.20 DC-12 GHz 1.30 12-18 GHz	SMA Male	.310	(0,787)	.450	(1,143)	0.1 oz.
9217F	1.20 DC-12 GHz 1.30 12-18 GHz	SMA Female	.210	(0,533)	.500	(1,270)	0.05 oz.

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50-OHM
2-WATT
COAXIAL TERMINATIONS

FEATURES

- low price
- rugged construction
- line covers all standard connectors

MATERIALS & FINISHES

All units fabricated in brass, silver-plated & rhodium-flashed

Contacts in beryllium copper, gold-plated
All materials & finishes to Govt. specs

SPECIFICATIONS (DC-5GC MODELS)

MODEL NUMBER	MAX. VSWR	CONNECTOR	MAX. DIMENSIONS DIA in.	MAX. DIMENSIONS DIA cm	MAX. DIMENSIONS LENGTH in.	MAX. DIMENSIONS LENGTH cm	WEIGHT
9200	1.15	N Male	.843	(2,143)	1.406	(3,571)	2 oz.
9200F	1.15	N Female	.750	(1,905)	1.484	(3,770)	2 oz.
9202	1.15	TNC Male	.578	(1,468)	1.109	(2,817)	3/4 oz.
9202F	1.15	TNC Female	.578	(1,468)	1.187	(3,016)	3/4 oz.
9203	1.15	BNC Male	.609	(1,547)	1.109	(2,817)	3/4 oz.
9203F	1.15	BNC Female	.609	(1,547)	1.187	(3,014)	3/4 oz.

SPECIFICATIONS (DC-12GC MODELS)

MODEL NUMBER	MAX. VSWR	CONNECTOR	MAX. DIMENSIONS DIA. in.	MAX. DIMENSIONS DIA. cm	MAX. DIMENSIONS LENGTH in.	MAX. DIMENSIONS LENGTH cm	WEIGHT
9210	1.20	N Male	.843	(2,141)	1.406	(3,571)	2 oz.
9210F	1.20	N Female	.750	(1,905)	1.484	(3,769)	2 oz.
9211	1.20	C Male	.750	(1,905)	1.406	(3,571)	2 oz.
9211F	1.20	C Female	.750	(1,905)	1.328	(3,373)	2 oz.
9212	1.20	TNC Male	.750	(1,905)	1.562	(3,968)	2 oz.
9212F	1.20	TNC Female	.750	(1,905)	1.437	(3,651)	2 oz.
9213	1.20	BNC Male	.750	(1,905)	1.593	(4,048)	2 oz.
9213F	1.20	BNC Female	.750	(1,905)	1.437	(3,649)	2 oz.

ALL MODELS: AVERAGE POWER 2 WATTS PEAK POWER 1 KW.

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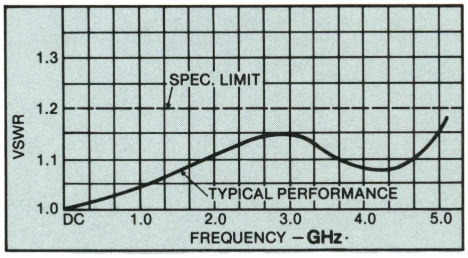
50-OHM
5-WATT
COAXIAL TERMINATIONS

FEATURES

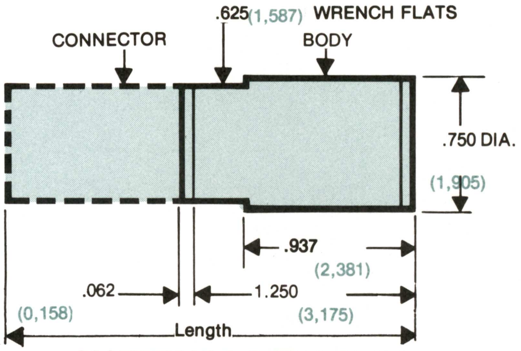
- 10 models covering DC-5 GHz
- low price
- rugged construction
- line covers all standard connectors

MODEL 9400

TYPICAL ELECTRICAL PERFORMANCE



MECHANICAL DATA



MATERIALS & FINISHES

All units fabricated in brass, silver-plated
& rhodium-flashed
Contacts in beryllium copper, gold-plated
All materials & finishes to Govt. specs

SPECIFICATIONS

MODEL NUMBER	MAXIMUM VSWR	CONNECTOR	MAXIMUM DIMENSIONS				WEIGHT
			DIAMETER in.	cm	LENGTH in.	cm	
9400	1.2	N Male	.750	(1,905)	1.875	(4,762)	2 oz.
9400F	1.2	N Female	.750	(1,905)	1.875	(4,762)	2 oz.
9402	1.2	TNC Male	.750	(1,905)	1.625	(4,127)	1 oz.
9402F	1.2	TNC Female	.750	(1,905)	1.625	(4,127)	1 oz.
9403	1.2	BNC Male	.750	(1,905)	1.625	(4,127)	1 oz.
9403F	1.2	BNC Female	.750	(1,905)	1.625	(4,127)	1 oz.
9404	1.2	HN Male	.750	(1,905)	2.125	(5,397)	2 oz.
9404F	1.2	HN Female	.750	(1,905)	2.125	(5,397)	2 oz.
9405	1.2	SC Male	.750	(1,905)	2.125	(5,397)	2 oz.
9405F	1.2	SC Female	.750	(1,905)	2.125	(5,397)	2 oz.

ALL MODELS: AVERAGE POWER—5 WATTS PEAK POWER—2.5 KW. FREQUENCY RANGE: DC-5 GHz

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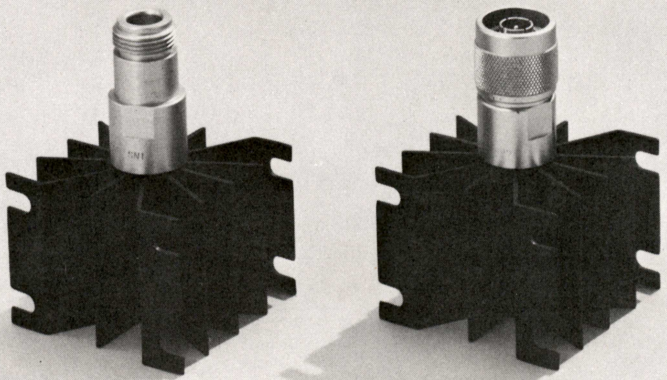
50-OHM
25-WATT
COAXIAL TERMINATIONS

FEATURES

- 6 models covering DC-5 GHz
- low price
- low VSWR
- built-in heat sinks
- rugged construction
- type N, BNC, & TNC connectors (male or female)

TYPE N MODELS SHOWN HERE

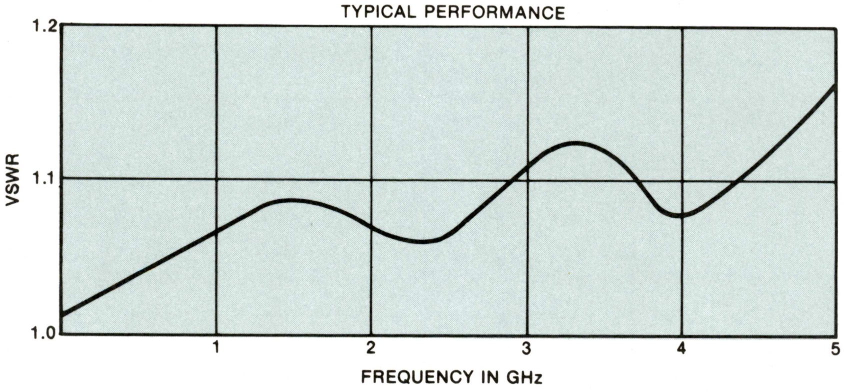


MODEL 9600 HF MODEL 9600 H

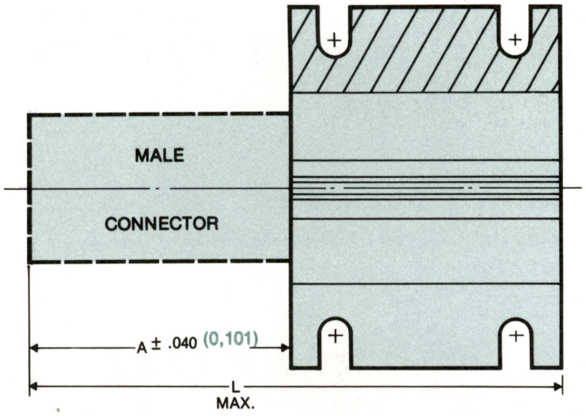
ELECTRICAL SPECIFICATIONS

Frequency Range	DC-5 GHz
VSWR	less than 1.2:1
Average Power Dissipation	25 watts
Peak Power Dissipation	2.5 KW

Note: Power ratings noted above are as measured with built-in heat sinks. On special order, the basic terminations can be supplied without heat sinks, so that they can be press-mounted into a standard 0.4965/0.4985 inch (1,262/1,267 centimeter) diameter hole in the customer's heat sink.

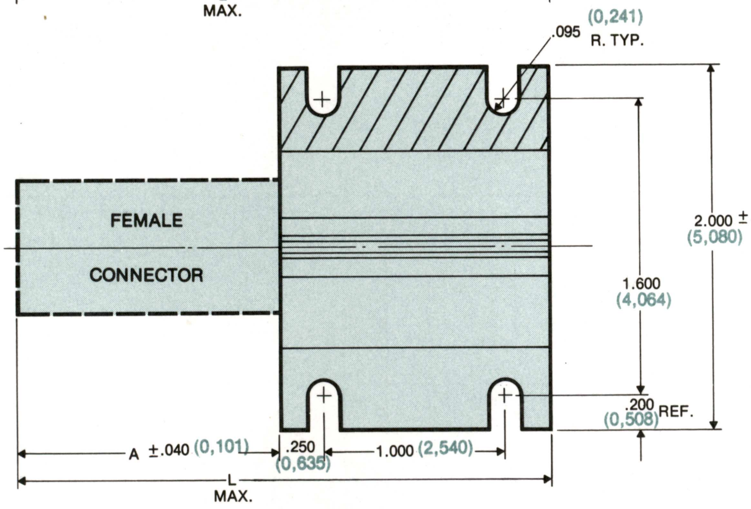


50-OHM 25-WATT COAXIAL TERMINATIONS - MECHANICAL DATA

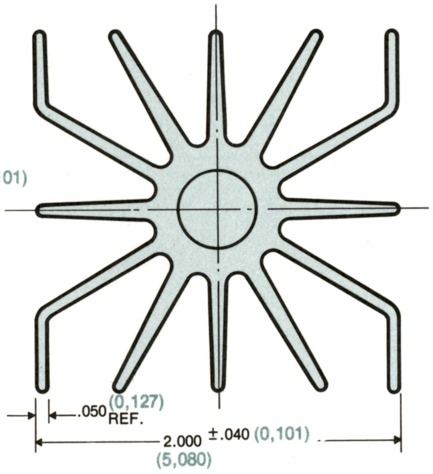


MALE
CONNECTOR
A ± .040 (0,101)
L
MAX.

9600 SERIES - TYPE N CONNECTORS
9602 SERIES - TYPE TNC CONNECTORS
9603 SERIES - TYPE BNC CONNECTORS
(SEE TABLE BELOW FOR SPECIFIC
MODELS AND DIMENSIONS)



.095 (0,241)
R. TYP.
FEMALE
CONNECTOR
2.000 ±.040 (0,101)
(5,080)
1.600
(4,064)
.200
(0,508)
REF.
A ±.040 (0,101)
.250
(0,635)
1.000 (2,540)
L
MAX.



.050 (0,127)
REF.
2.000 ±.040 (0,101)
(5,080)

MODEL NUMBER	CONNECTOR TYPE	CONNECTOR LENGTH A in.	CONNECTOR LENGTH A cm	OVERALL LENGTH L in.	OVERALL LENGTH L cm
9600-H	MALE TYPE N	1.33	(3,378)	3.00	(7,620)
9600-HF	FEMALE TYPE N	1.41	(3,581)	3.00	(7,620)
9602-H	MALE TYPE TNC	1.47	(3,733)	3.20	(8,128)
9602-HF	FEMALE TYPE TNC	1.17	(2,971)	2.90	(7,366)
9603-H	MALE TYPE BNC	1.47	(3,733)	3.20	(8,128)
9603-HF	FEMALE TYPE BNC	1.17	(2,971)	2.90	(7,366)

MATERIALS & FINISHES

Connectors brass, nickle-plated.
Heat sinks aluminum, black anodized (except for cross-hatched areas, which are unfinished to provide good ground)

OPTIONS

(1) Male or female N, TNC, or BNC connectors, as shown above.
(2) On special order, the basic terminations can be supplied without heat sinks, for press-mounting into a standard 0.4965/0.4985 inch (1,262/1,267 centimeter) diameter hole in your own heat sink.

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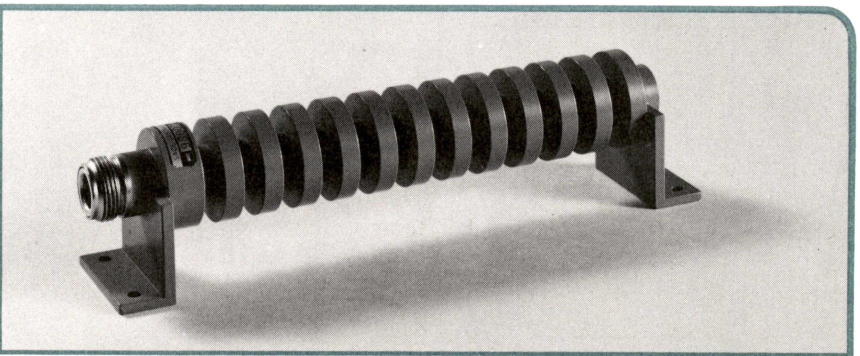
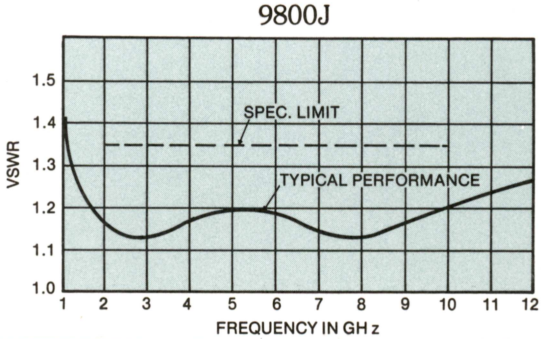
50 OHM
200 WATT
COAXIAL TERMINATION
MODEL 9800J

FEATURES

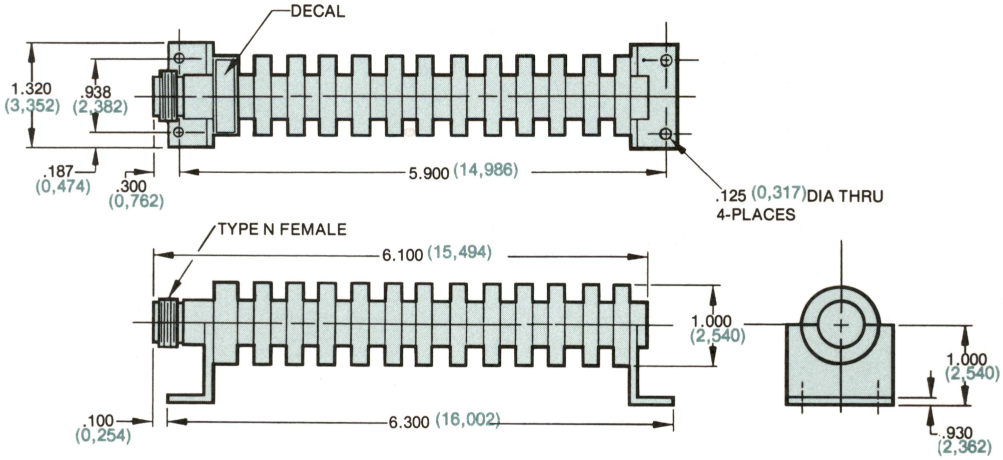
- air-cooled
- high power (200 watt average - 1 KW peak)
- broadband (2-10 GHz at full power)
- moderate VSWR (1.35)



ELECTRICAL SPECIFICATIONS



MECHANICAL DATA


DECAL
1.320 (3,352)
.938 (2,382)
.187 (0,474)
.300 (0,762)
5.900 (14,986)
.125 (0,317) DIA THRU
4-PLACES
TYPE N FEMALE
6.100 (15,494)
1.000 (2,540)
.100 (0,254)
6.300 (16,002)
1.000 (2,540)
.930 (2,362)

MATERIALS & FINISHES

Bodies fabricated in aluminum for maximum heat conductivity

All metals silverplated & rhodium-flashed

All SAGELINE materials & finishes to Gov. specs

Alternative materials & finishes supplied on special order

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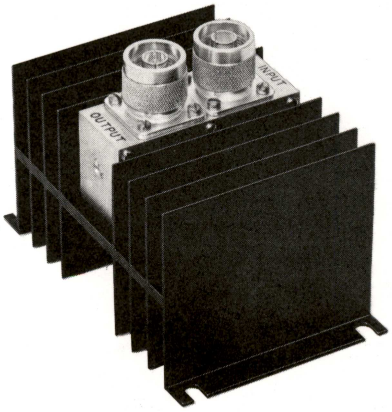
50-OHM HIGH POWER COAXIAL ATTENUATORS

FEATURES

- 3, 6, 10 and 20 dB models covering DC-2 GHz
- compact
- available with or without heat sink
- high power - (5 KW peak)
- controlled attenuation vs frequency slope can provide system compensation



ELECTRICAL SPECIFICATIONS

	MAXIMUM VSWR			NOMINAL ATTENUATION (dB) (DEVIATION FROM NOMINAL: ±5%)				AVERAGE INPUT POWER RATING AT 55°C**
MODEL*	DC-1GHz	1-1.5GHz	1.5-2GHz	DC	1GHz	1.5GHz	2.0GHz	
9990-3	1.25	1.30	1.30	3.0	3.3	3.9	4.6	100 Watts
9990-6	1.15	1.20	1.30	6.0	6.3	6.6	7.3	60 Watts
9990-10	1.15	1.20	1.20	10.0	10.0	10.1	10.2	50 Watts
9990-20	1.20	1.20	1.25	20.0	18.5	16.5	14.5	50 Watts

*9990 models have Male/Female Type N connectors

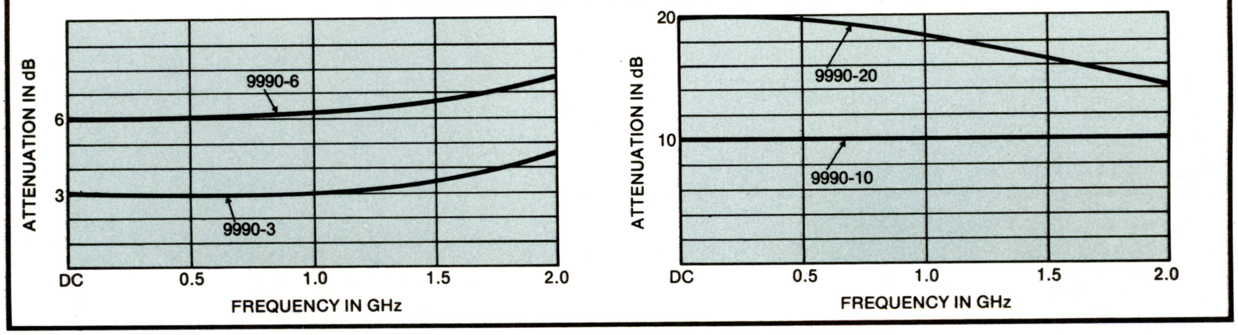
Specify 9990M for Male/Male Type N connectors (9990M-3, 6, 10, 20)

Specify 9990F for Female/Female Type N connectors (9990F-3, 6, 10, 20)

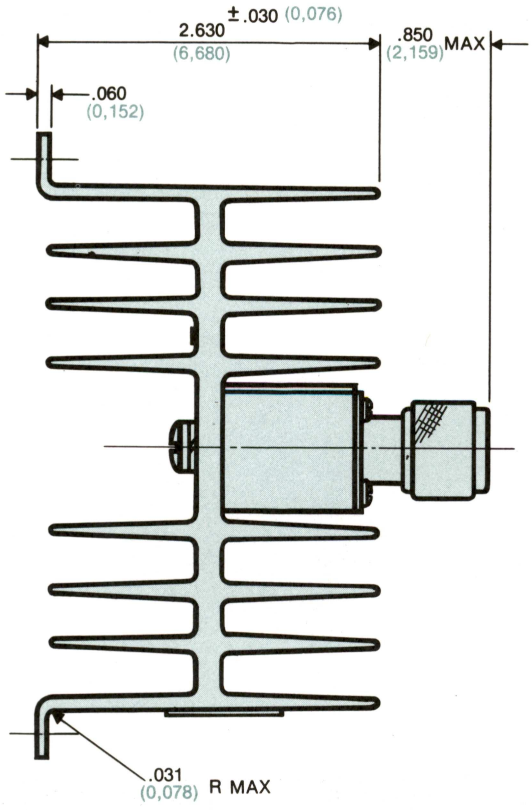
**Derate average power to zero at 150°C. Peak power is 5 KW.

Heat sink temperature rise with natural convection is 1.3°C per watt dissipation.

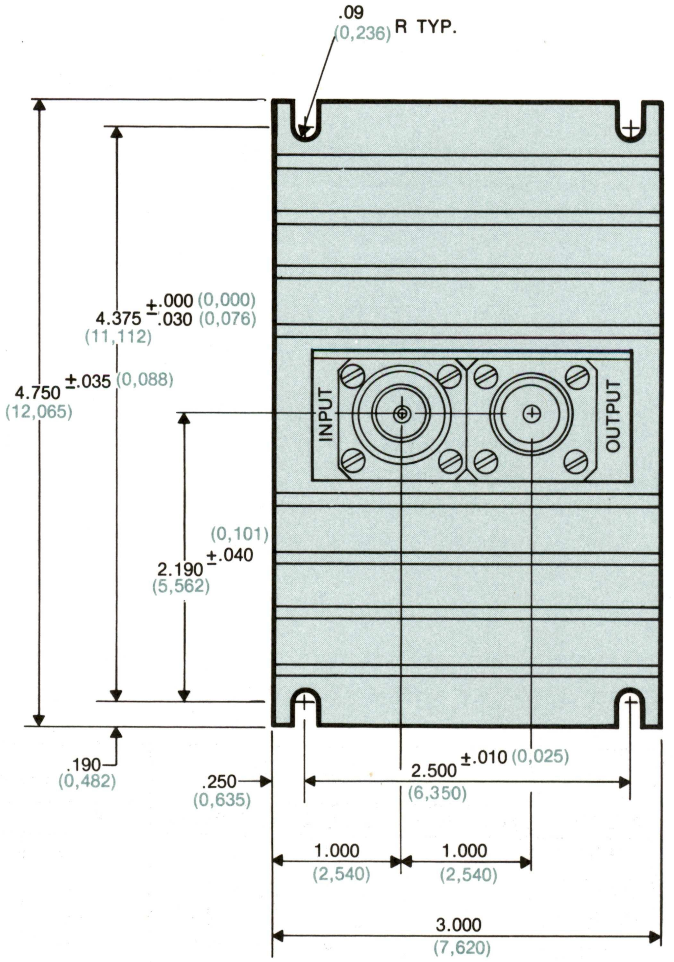
TYPICAL PERFORMANCE DATA



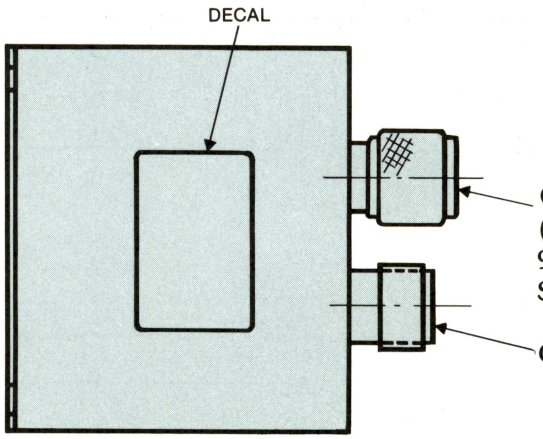
9990 SERIES ATTENUATORS - MECHANICAL DATA



2.630 ±.030 (0,076)
(6,680)
.850 (2,159) MAX
.060
(0,152)
.031 (0,078) R MAX



.09 (0,236) R TYP.
4.375 +.000 (0,000) −.030 (0,076)
(11,112)
4.750 ±.035 (0,088)
(12,065)
INPUT
OUTPUT
(0,101)
2.190 ±.040
(5,562)
.190
(0,482)
.250
(0,635)
2.500 ±.010 (0,025)
(6,350)
1.000
(2,540)
1.000
(2,540)
3.000
(7,620)



CONNECTOR MALE N
(CONNECTOR CONFIGURATION SHOWN IS FOR 9990 MODELS - SEE NOTE BELOW ELECTRICAL SPECS TABLE)

CONNECTOR FEMALE N

WEIGHT	WITH HEAT SINK	WITHOUT HEAT SINK
Ounces	15.0	5.5
Grams	425	156

NOTE: Units can be supplied without heat sinks for direct mounting on customer's heat sink. Basic unit measures 2.625" x 1.25" x 1" (6,667 x 3,175 x 2,54 cm) excluding connectors. Two #10-32 mounting holes are located on 2.00" (5,08 cm) centers.

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POWER DIVIDERS

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A Guide to Power Divider Selection **133-134**
Custom Engineering Capabilities **135-139**
Standard Products **140-154**

A GUIDE TO POWER DIVIDER SELECTION

All power dividers described in this section of the catalog are equal power dividers which have low forward insertion loss, low VSWR on all ports, and isolation between output ports. All designs presented here are fabricated using etched microstrip circuitry which is amenable to low cost volume production. Their major limitation is power dissipation in the internal resistor element used to provide isolation and low VSWR at the output ports. Other divider types suitable for high power are discussed on the next page. (Conventional Sage TEM coupled-line hybrids and couplers, which handle higher power levels while also providing the isolation, VSWR and loss characteristics of the microstrip designs, are not shown in this section. See HYBRIDS & COUPLERS section.)

Sage Laboratories has developed two techniques to minimize insertion loss while retaining the cost advantages of microstrip construction. In the first technique, advantage is taken of each element in a multiple-way divider to minimize the total number of elements for a given VSWR and bandwidth. (This design technique is explained in detail in a reprint of “Binary Power-Divider Design Approach” by Harry F. Chapell, Chief Engineer of Sage Laboratories. This paper is included in the next section under CUSTOM ENGINEERING CAPABILITIES.) The second technique for minimizing insertion loss is exemplified by our Model FP1513-12 three-way divider, which uses one-step three-way power division, as opposed to cascaded unequal dividers. This design technique provides true three-way power division with only transmission line losses in the circuit.

Phase Balance. All units described in this section of the catalog use in-phase dividing networks. In order to minimize insertion loss, in some cases, the internal 50-ohm transmission lines connected to the several outputs are of different lengths. The resultant path-length unbalance can be compensated for in the mating cable assemblies. If phase is a specified parameter in your application, please consult us before you order.

A GUIDE TO POWER DIVIDER SELECTION (Continued)

Although most standard Sage power dividers have limited power dissipation, we do manufacture other types, both as standards and specials, which could be more suitable in certain high power applications. These other types include *reactive dividers*, *ring hybrids*, and *modified ring hybrids*.

Reactive Dividers divide input power into any desired number of outputs with perfect division and equal phase. Transformers are used to match the input VSWR. The output VSWR is relatively high. This can produce phase or amplitude imbalance if the load matches differ. Isolation between outputs is relatively low. The trade-offs are simplicity, reliability, and high power handling capability (due to the absence of internal terminations). Examples of Sage reactive dividers are model numbers 596 and FH843, both of which are described in the next section, CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS.

Ring Hybrids. The classic ring hybrid is a simple device which can provide either in-phase or out-of-phase outputs. Its disadvantages are variations in phase and balance away from the center frequency. It has the advantages of providing a match on all ports, isolation between outputs, and the ability to use an external termination of a suitable size for a given power requirement. An example of the ring hybrid is Sage model FH2102, which is described in the next section, CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS.

Modified Ring Hybrids. If an in-phase divider is required, the ring hybrid can be modified to provide a perfectly symmetric unit having perfect balance with frequency. The modified unit retains the isolation between outputs and the matched port characteristics of the standard ring hybrid. External terminations can be used to handle any required level of reflected power. Examples of modified ring hybrids are Sage model FP2172 (CUSTOM ENGINEERING CAPABILITIES section) and Sage models FP2066 and FP2139 (standard 420-450 MHz COMMUNICATIONS BAND POWER DIVIDERS).

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CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS

As was noted under A GUIDE TO POWER DIVIDER SELECTION, the following MTT paper illustrates one Sage technique for minimizing power divider insertion loss while retaining the cost advantages of microstrip construction.

Binary Power-Divider Design Approach

Harry F. Chapell

Abstract—Utilizing all sections of binary power dividers in a single transformer yields a reduced circuit length for a specified electrical performance.

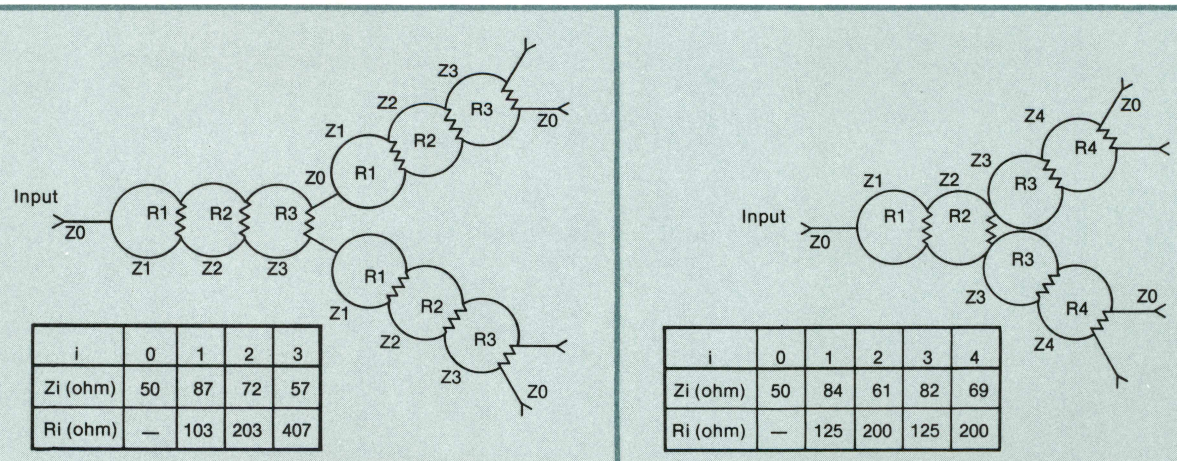
Yee et al. have presented tables for a wide range of *N*-way three-dimensional step-transformer power dividers [1]. This short paper suggests a method of achieving equivalent performance in two-dimensional binary power dividers.

Two design examples are given to illustrate the technique.

Example 1: A four-way divider is required to cover 1-2.6 GHz. A 0.9-2.7-GHz 1.2/1 maximum-VSWR design bandwidth was chosen to allow for production tolerances. If cascaded, randomly spaced two-way dividers (whose terminals are matched to 50 Ω) are used, each divider will require a three-section step transformer. The overall circuit length will be at least 1.5 wavelengths. On the other hand, a four-section transformer with a four-to-one impedance ratio has a theoretical VSWR of 1.09/1 maximum over a 0.9-2.7-GHz frequency range. The total circuit length can be as short as one wavelength, which represents a 30-percent reduction in size and insertion loss. Impedance values for the two approaches are shown in Fig. 1. The transmission-line impedances were obtained from tables of step-impedance transformers [1]. For a three-to-one bandwidth ratio, the normalized step admittances from the tables are 0.2973, 0.4102, 0.6094, and 0.8409. The first two are doubled to account for the effective paralleling of the lines in the circuit shown in Fig. 1(b), yielding 0.5946 and 0.8204. After taking reciprocals to obtain normalized impedance and after denormalizing by multiplying by 50 Ω, the values shown in Fig. 1(b) were obtained. Although Yee *et al.* give normalized values for the shunt resistors, which were used to obtain the values for Fig. 1(a), the tables are not applicable to the circuit of Fig. 1(b). Shunt-resistor values were obtained empirically for this case. Production dividers constructed from the four transformer step design provided a comfortable margin against specification limits of 1.45/1 maximum input and output VSWR, 1-dB-maximum insertion loss (excluding coupling loss), and 20-dB-minimum isolation between outputs.

In fairness, it should be noted that, if the three-section two-way dividers are cascaded with zero line length between them, the VSWR of the cascade will be better than the worst-case condition of random length between the dividers. However, at higher frequencies, for physical realizability, a length of line between the cascaded dividers is desirable. The approach suggested in this short paper can still be applied to advantage.

Example 2: A four-way divider is required for 3.7-4.2 GHz. A three-section 4-to-1 impedance-ratio prototype was se-

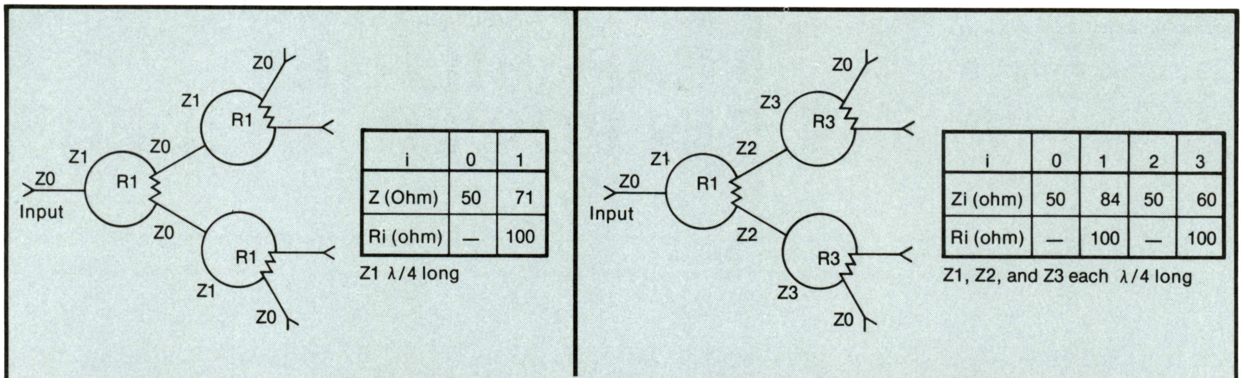


i	0	1	2	3
Zi (ohm)	50	87	72	57
Ri (ohm)	—	103	203	407

i	0	1	2	3	4
Zi (ohm)	50	84	61	82	69
Ri (ohm)	—	125	200	125	200

Fig. 1. Impedance values for 0.9-2.7-GHz 4-way dividers. (a) Cascaded 3 transformer-section 2-way dividers. (b) 4 transformer-section 4-way dividers.

CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS (Continued)



i	0	1
Z (Ohm)	50	71
Ri (ohm)	—	100

Z1 λ/4 long

i	0	1	2	3
Zi (ohm)	50	84	50	60
Ri (ohm)	—	100	—	100

Z1, Z2, and Z3 each λ/4 long

Fig. 2. Impedance values for 3.7-4.2-GHz 4-way dividers. (a) Cascaded single-section 2-way dividers. (b) 3 transformer-section 4-way dividers.

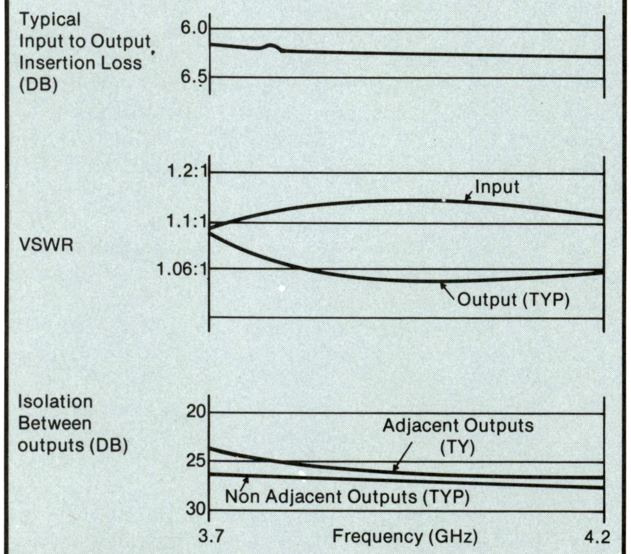


Fig. 3. Three transformer-section 4-way power dividers.

lected. With a normalized bandwidth of 0.2, the theoretical maximum VSWR is 1.02/1. With cascaded single-section transformer dividers, the VSWR over the same bandwidth would vary between 1.03/1 (with no length between the dividers), 1.24/1 maximum (with a quarter-wavelength between the dividers), and 1.12/1 maximum (with a half-wavelength between the dividers).

Fig. 2 shows impedance values for the two approaches. Fig. 3 gives typical performance of the three transformer-section design.

Summarizing, a significant improvement in the performance of a set of cascaded power dividers can be achieved by considering the entire chain as a multistep transformer, rather than designing each divider to be matched to 50Ω at its input and output.

REFERENCES

[1] H. Yee, F. Chang, and N. Audeh, "A study of wideband *N*-way power dividers," Univ. Ala. Res. Inst., ASTIA AD693290, July 1969

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Vol. MTT-22, No. 5, May 1974, pp. 580-581
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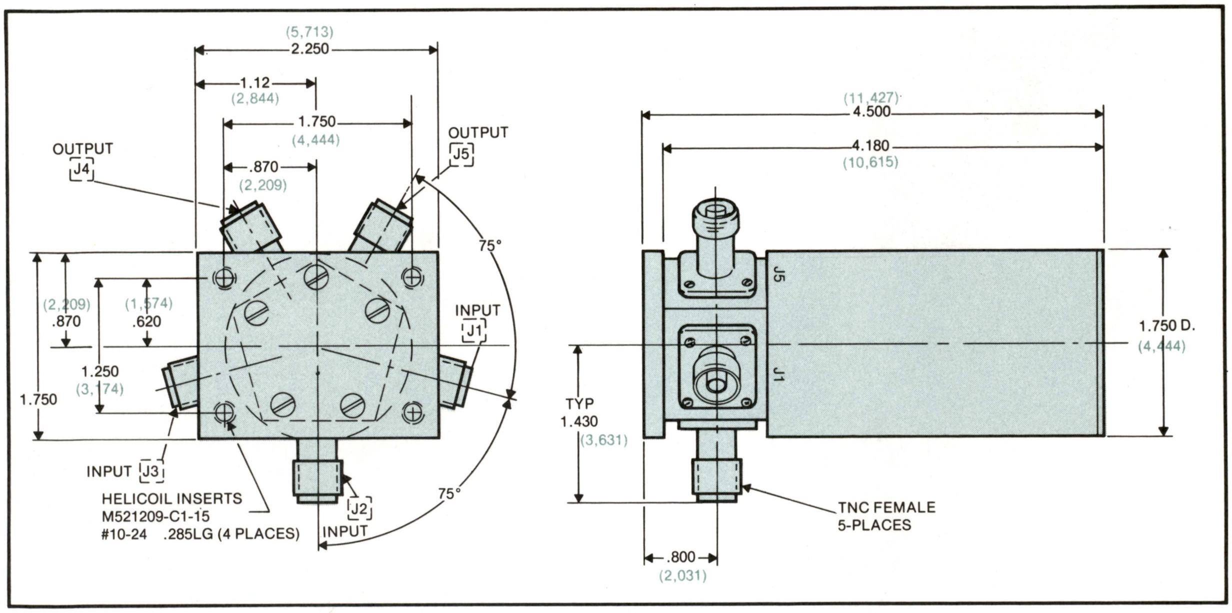
Manuscript received September 26, 1973; revised January 3, 1974
The author is with Sage Laboratories, Inc., Natick, Mass. 01760.

CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS (Continued)

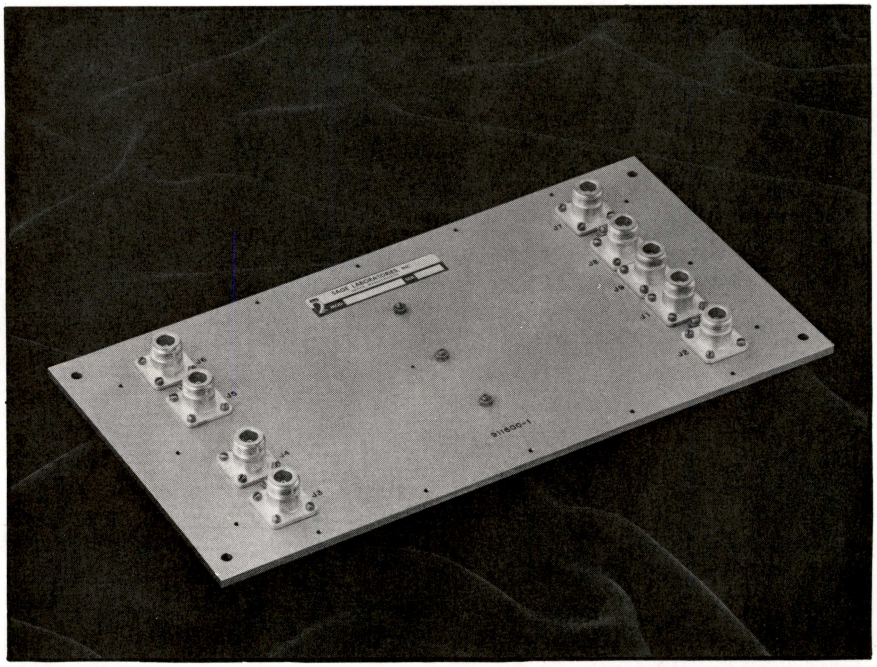
WIRELINE™ USED IN 3-INPUT, 2-OUTPUT ANTENNA MULTICOUPLER


(5,713)
2.250
1.12
(2,844)
1.750
(4,444)
.870
(2,209)
OUTPUT J4
OUTPUT J5
75°
INPUT J1
(2,209)
.870
(1,574)
.620
1.250
(3,174)
1.750
INPUT J3
HELICOIL INSERTS
M521209-C1-15
#10-24 .285LG (4 PLACES)
J2
INPUT
75°
(11,427)
4.500
4.180
(10,615)
J5
J1
1.750 D.
(4,444)
TYP
1.430
(3,631)
TNC FEMALE
5-PLACES
.800
(2,031)

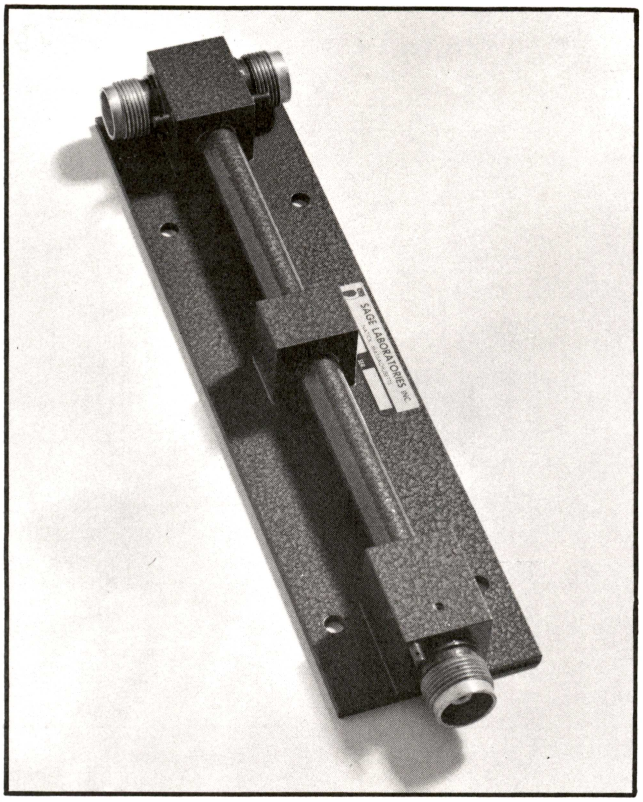
Model FH735 3-input 2-output antenna multicoupler uses cascaded Wilkinson power dividers of WIRELINE construction. The operating frequency range is 487-595 MHz. VSWR is 1.5:1 maximum, and insertion loss is 8.5 dB maximum. The phase imbalance is ±1 degree maximum, and the isolation between outputs is 20 dB minimum.

MEDIUM POWER 8-WAY UHF DIVIDER FOR PHASED ARRAY

Model FP2066-2 provides an in-phase 8-way power division from 420-450 MHz. Typical performance features include 0.15-dB insertion loss, 1.1:1 input VSWR, and less than 1.05:1 output VSWR. Isolation between outputs is 25 dB minimum. Input power rating is 80 watts peak, 20 watts average, with the outputs terminated in short circuits of any phase. The unit is shown about 1/4 actual size. The application was phased-array radar.



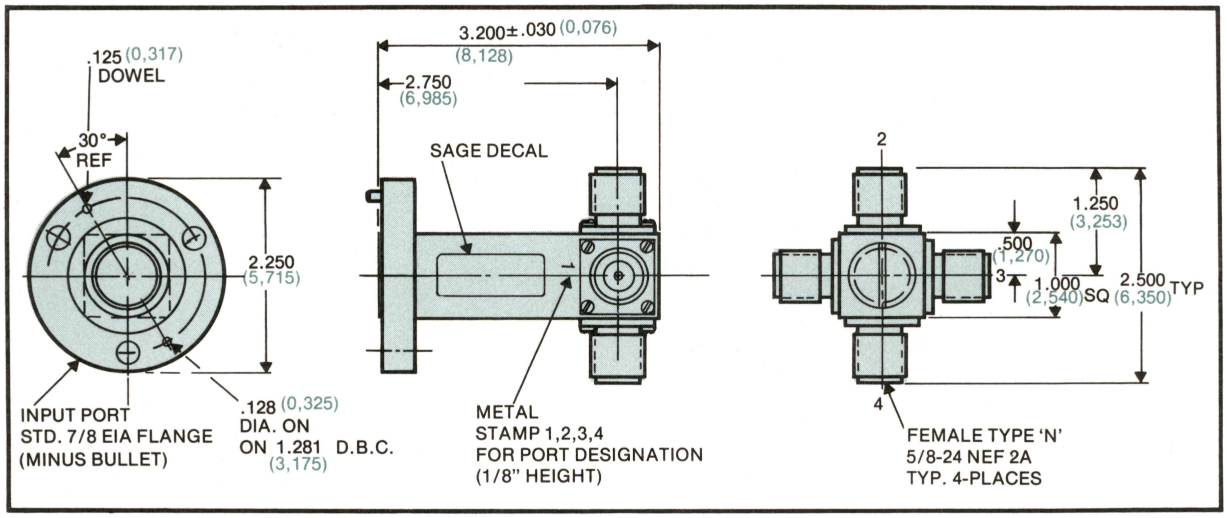
CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS (Continued)



HIGH POWER REACTIVE DIVIDER FOR TITAN II PROGRAM

Model 596 is a 225-260 MHz space-qualified reactive power divider for which Sage-Labs' in-house dip brazing capabilities were used to full advantage. VSWR is 1.3:1. The unit is rated at 200 watts c-w signal input. Power split is 2.8-3.3 dB, and phase balance is held within ±3 degrees.

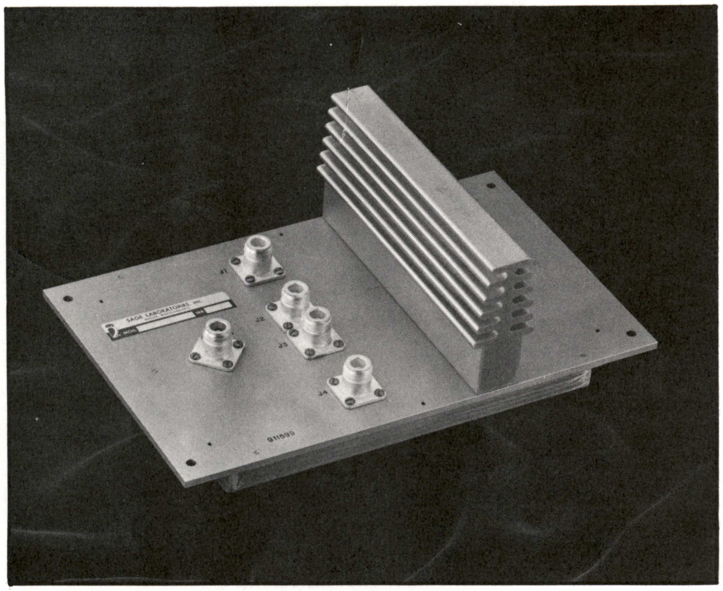
A reactive divider of this type has no internal terminations; therefore, its average and peak power handling capability are limited only by connector capability.


.125 (0,317)
DOWEL
30°
REF
2.250
(5,715)
INPUT PORT
STD. 7/8 EIA FLANGE
(MINUS BULLET)
.128 (0,325)
DIA. ON
ON 1.281 D.B.C.
(3,175)
3.200±.030 (0,076)
(8,128)
2.750
(6,985)
SAGE DECAL
1
METAL
STAMP 1,2,3,4
FOR PORT DESIGNATION
(1/8" HEIGHT)
2
3
4
1.250
(3,253)
.500
(1,270)
1.000
(2,540) SQ
2.500
(6,350) TYP
FEMALE TYPE 'N'
5/8-24 NEF 2A
TYP. 4-PLACES

ANOTHER EXAMPLE OF THE COMPACTNESS & POWER HANDLING OF SIMPLE REACTIVE DIVIDERS

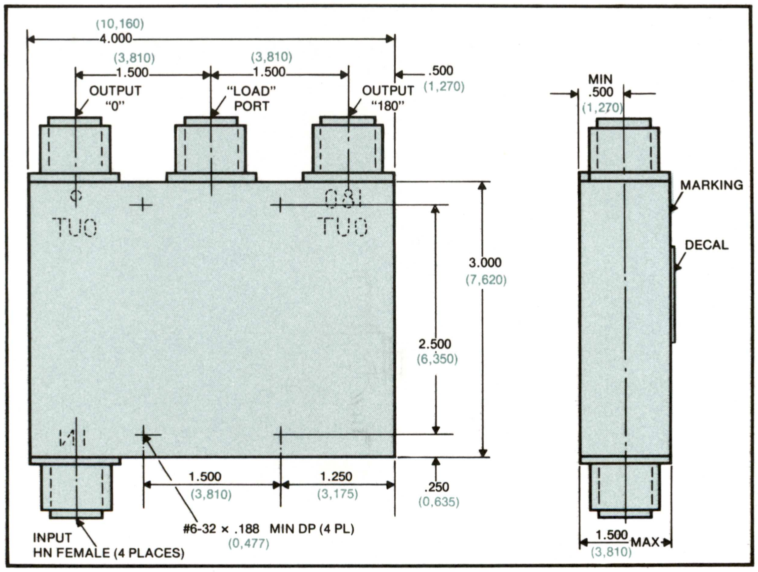
Model FH843 demonstrates how well simple reactive dividers meet the need when output VSWR and isolation between outputs are not critical. Model FH843 provides four in-phase outputs, equal in amplitude within 0.1 dB, over the 900-930 MHz band. Input power rating is 32 KW peak; 1.6 KW average. Input VSWR is 1.2:1 maximum.

CUSTOM ENGINEERING CAPABILITIES IN POWER DIVIDERS (Continued)



4-WAY DIVIDER WITHSTANDS OPEN & SHORT CIRCUIT OUTPUTS

Model FP2066-3 is a medium power 4-way UHF power divider which safely dissipates reflected power at all phases of an output open or short circuit with input power levels of 365 watts peak and 91 watts average. Frequency range is 420-450 MHz. Power is divided equally and in-phase among the four outputs. Insertion loss is 0.2 dB maximum. VSWR is 1.1:1 maximum. Isolation between ports is 30 dB minimum. The unit measures 11.5 inches long by 7 inches wide by 3.25 inches high.


(10,160)
4.000
(3,810)
1.500
(3,810)
1.500
.500
(1,270)
OUTPUT "0"
"LOAD" PORT
OUTPUT "180"
OUT
180 OUT
IN
3.000
(7,620)
2.500
(6,350)
1.500
(3,810)
1.250
(3,175)
.250
(0,635)
#6-32 × .188 MIN DP (4 PL)
(0,477)
INPUT
HN FEMALE (4 PLACES)
MIN
.500
(1,270)
MARKING
DECAL
1.500 MAX
(3,810)

THE RING HYBRID - AN OLD DESIGN CONCEPT THAT CONTINUES TO FIND APPLICATIONS IN TODAY'S NEEDS

In the continuing quest for newness, the attributes of the simple ring hybrid are sometimes overlooked. Model FH2102 is an example of ring hybrid construction applied to a potted stripline assembly. The unit withstands 8 KW peak input power at altitudes of 80,000 feet. The operating frequency of the unit shown is 1225±25 MHz. VSWR is 1.35:1 maximum, and maximum insertion loss is 0.3 dB. Maximum amplitude imbalance is 0.2 dB. The phase relationship between outputs is 180 degrees, ±4 degrees maximum deviation. Isolation between outputs is 25 dB minimum.

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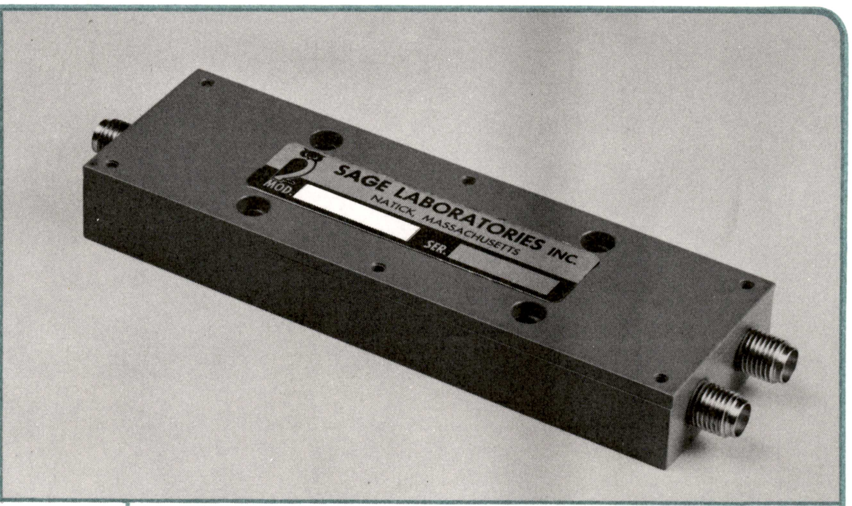
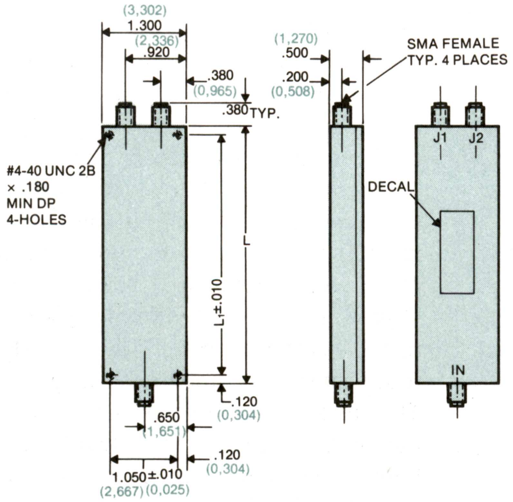
ISOLATED OUTPUT EQUAL POWER DIVIDERS 2-WAY

FEATURES

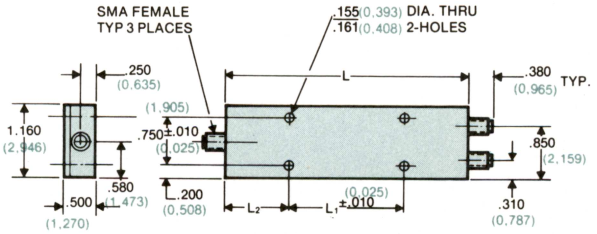
- series covers 1-10.8 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- passivated stainless steel connectors with interface per MIL-C39012


MOD.
SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
SER.

MECHANICAL DATA - FP1512 SERIES

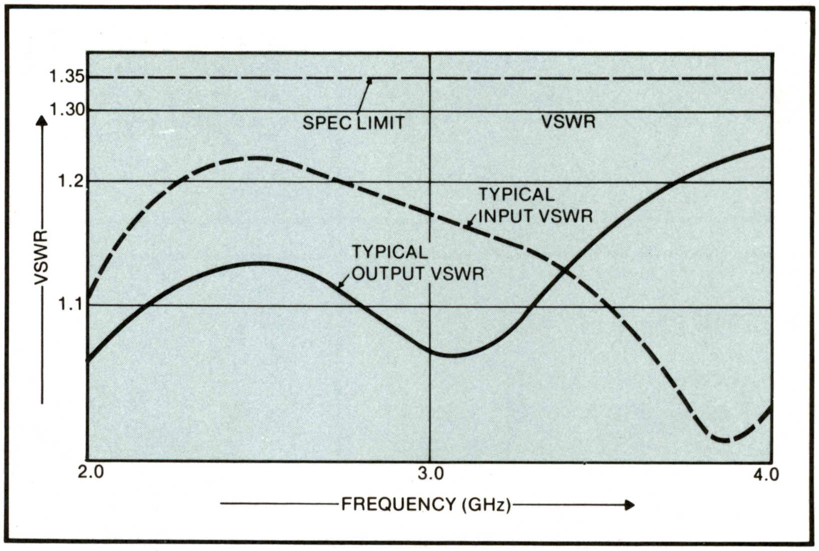

(3,302)
1.300
(2,336)
.920
.380
(0,965)
.380 TYP.
(1,270)
.500
.200
(0,508)
SMA FEMALE
TYP. 4 PLACES
#4-40 UNC 2B
× .180
MIN DP
4-HOLES
L
L1±.010
J1
J2
DECAL
IN
.120
(0,304)
.650
(1,651)
.120
(0,304)
1.050±.010
(2,667) (0,025)

MECHANICAL DATA - FP2369 SERIES

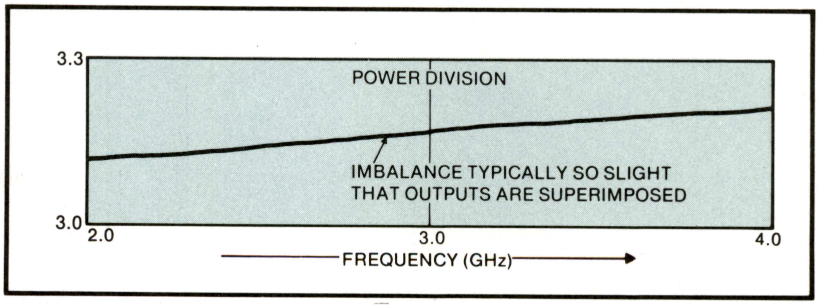

SMA FEMALE
TYP 3 PLACES
.155 (0,393) DIA. THRU
.161 (0,408) 2-HOLES
.250
(0,635)
L
.380
(0,965)
TYP.
1.160
(2,946)
(1,905)
.750±.010
(0,025)
.850
(2,159)
.580
(1,473)
.500
(1,270)
.200
(0,508)
L2
L1±.010
(0,025)
.310
(0,787)

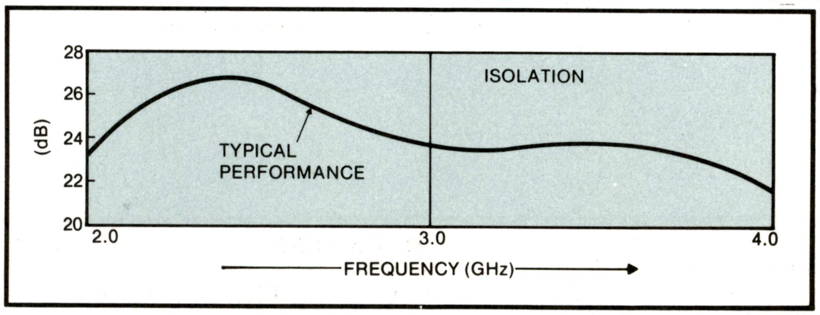
MODEL NUMBER	FREQUENCY RANGE (GHz)	DIMENSIONS					
		L"	L (cm)	L_1"	L_1 (cm)	L_2"	L_2 (cm)
FP1512-12	1-2	4.00	(10,160)	3.750	(9,525)	N.A.	N.A.
FP1512-24	2-4	2.30	(5,842)	2.050	(5,207)	N.A.	N.A.
FP1512-48	4-8	1.60	(4,064)	1.350	(3,429)	N.A.	N.A.
FP2369-2	1-2.6	3.74	(9,499)	1.750	(4,445)	.990	(2,514)
FP2369-4	2.3-4.4	1.98	(5,029)	N.A.	N.A.	.990	(2,514)
FP2369-1	4.3-7.3	1.52	(3,860)	N.A.	N.A.	.760	(1,930)
FP2369-5	7.2-10.8	1.42	(3,606)	N.A.	N.A.	.710	(1,803)

2-WAY EQUAL POWER DIVIDERS - ELECTRICAL SPECIFICATIONS



MODEL NUMBER	FREQUENCY RANGE (GHz)	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM INPUT VSWR	MAXIMUM OUTPUT VSWR	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP1512-12	1-2	0.3 dB	1.35:1	1.35:1	20	0.2
FP1512-24	2-4	0.3 dB	1.35:1	1.35:1	20	0.2
FP1512-48	4-8	0.3 dB	1.35:1	1.35:1	20	0.2
FP2369-2	1-2.6	0.4 dB	1.25:1	1.25:1	20	0.2
FP2369-4	2.3-4.4	0.4 dB	1.25:1	1.30:1	20	0.2
FP2369-1	4.3-7.3	0.5 dB	1.35:1	1.40:1	20	0.3
FP2369-5	7.2-10.8	0.6 dB	1.50:1	1.35:1	20	0.4





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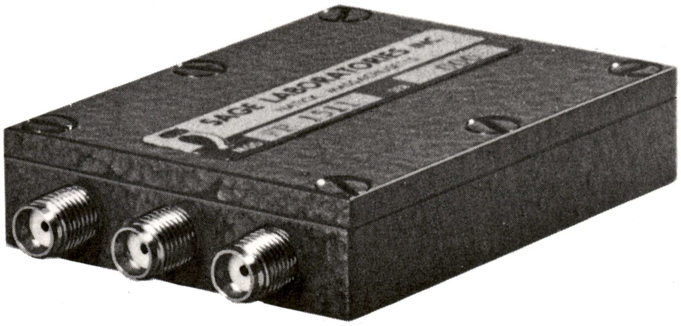
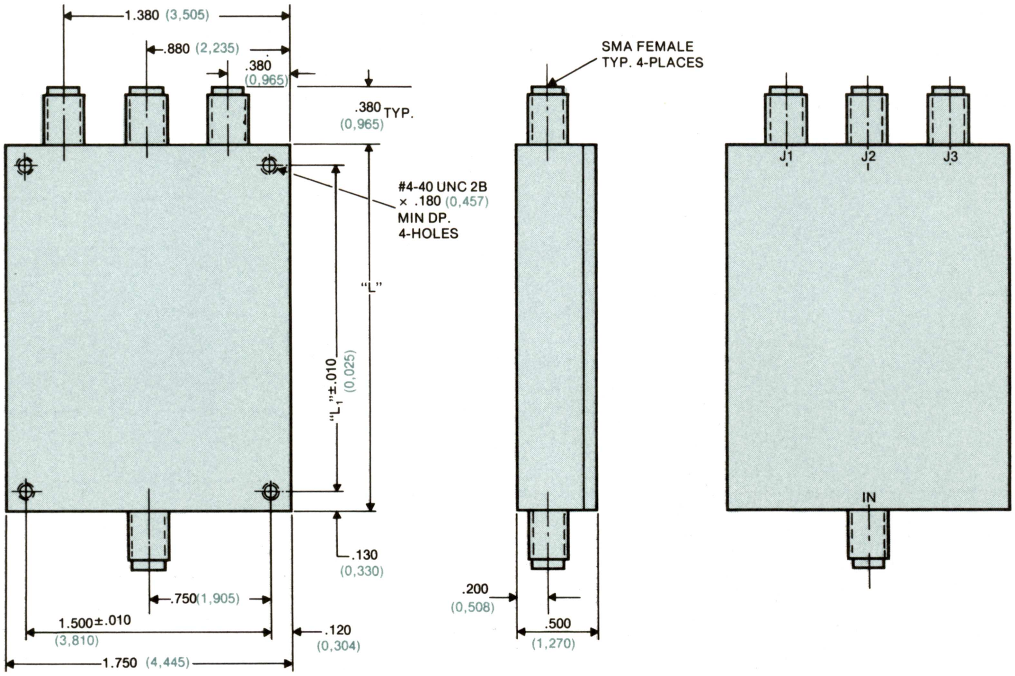
ISOLATED OUTPUT EQUAL POWER DIVIDERS 3-WAY

FEATURES

- series covers 1-8 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- passivated stainless steel connectors with interface per MIL-C-39012

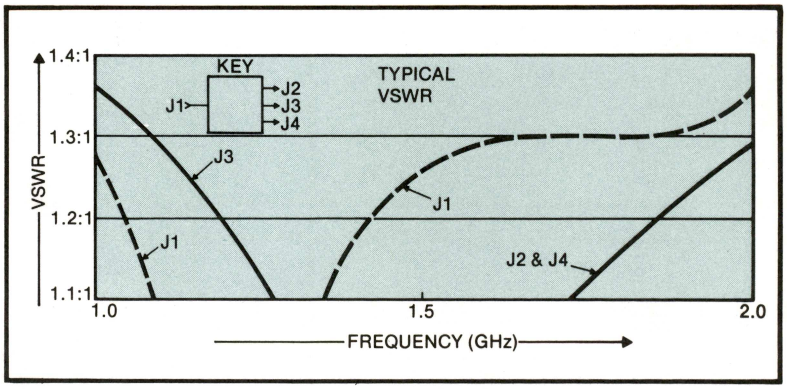


MECHANICAL DATA

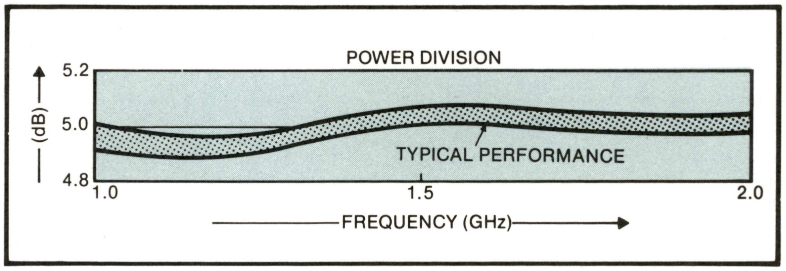

1.380 (3,505)
.880 (2,235)
.380 (0,965)
.380 TYP. (0,965)
#4-40 UNC 2B × .180 (0,457) MIN DP. 4-HOLES
"L"
"L1"±.010 (0,025)
.130 (0,330)
.750 (1,905)
1.500±.010 (3,810)
.120 (0,304)
1.750 (4,445)
SMA FEMALE TYP. 4-PLACES
.200 (0,508)
.500 (1,270)
J1
J2
J3
IN

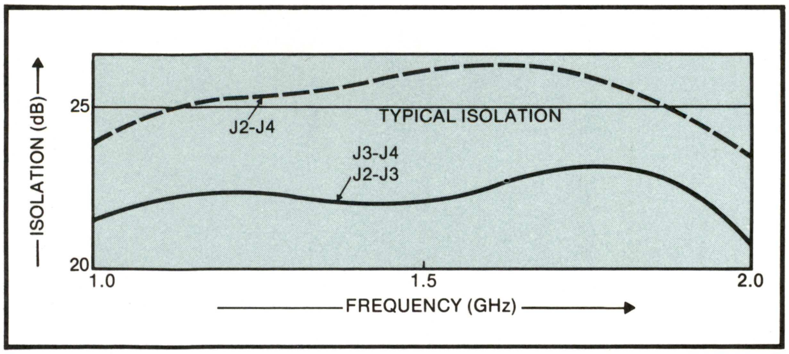
		DIMENSIONS			
MODEL NUMBER	FREQUENCY RANGE (GHz)	L"	L (cm)	L_1"	L_1 (cm)
FP1513-12	1-2	3.82	(9,703)	3.55	(9,017)
FP1513-24	2-4	2.42	(6,147)	2.15	(5,461)
FP1513-48	4-8	1.75	(4,445)	1.48	(3,759)

3-WAY EQUAL POWER DIVIDERS - ELECTRICAL SPECIFICATIONS



MODEL NUMBER	FREQUENCY RANGE (GHz)	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP1513-12	1-2	0.3 dB	1.5:1	19	0.5
FP1513-24	2-4	0.5 dB	1.5:1	19	0.5
FP1513-48	4-8	0.5 dB	1.6:1	16	0.5





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TEL: 617-653-0844 • TWX: 710-346-0390

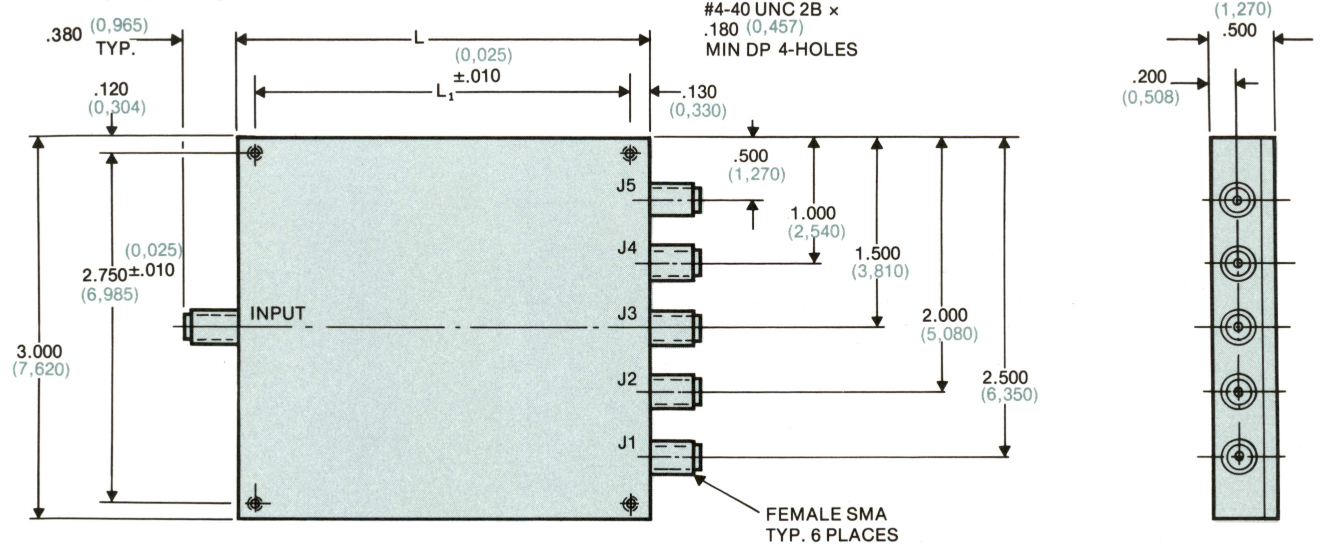
ISOLATED OUTPUT EQUAL POWER DIVIDERS 5-WAY

FEATURES

- true 5-way division
- low loss
- series covers 1-8 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- passivated stainless steel connectors with interface per MIL-C-39012

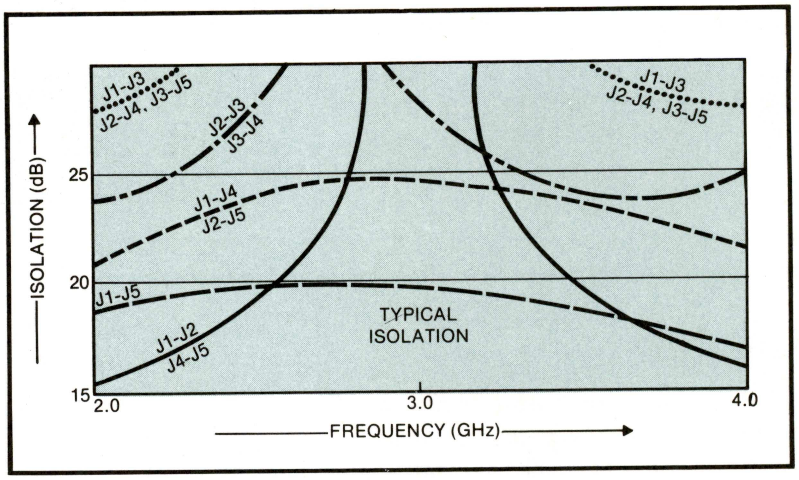
J1
J2
J3
J4
J5
SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS
MOD. P1835-24
SER.
INPUT

MECHANICAL DATA

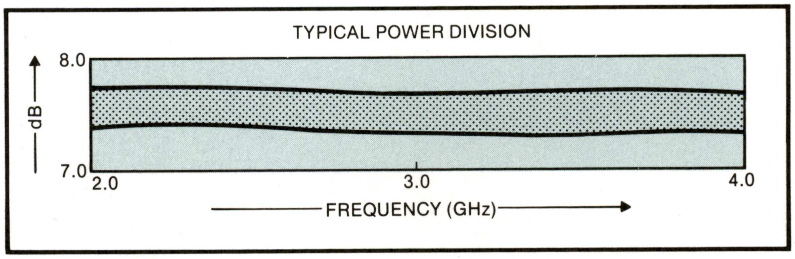

.380 (0,965) TYP.
L
(0,025) ±.010
L1
.120 (0,304)
.130 (0,330)
#4-40 UNC 2B × .180 (0,457) MIN DP 4-HOLES
.500 (1,270)
1.000 (2,540)
1.500 (3,810)
2.000 (5,080)
2.500 (6,350)
J5
J4
J3
J2
J1
INPUT
(0,025) 2.750±.010 (6,985)
3.000 (7,620)
FEMALE SMA TYP. 6 PLACES
(1,270) .500
.200 (0,508)

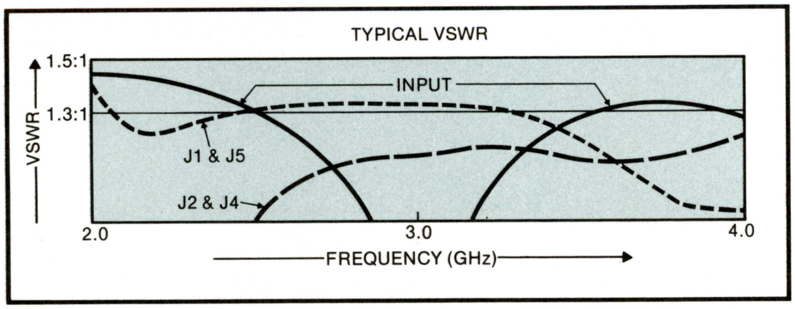
MODEL NUMBER	FREQUENCY RANGE (GHz)	DIMENSIONS			
		L"	L (cm)	L_1"	L_1 (cm)
FP1835-12	1-2	5.38	(13,665)	5.116	(12,995)
FP1835-24	2-4	3.20	(8,128)	2.936	(7,457)
FP1835-48	4-8	2.25	(5,715)	1.986	(5,044)

5-WAY EQUAL POWER DIVIDERS - ELECTRICAL SPECIFICATIONS



MODEL NUMBER	FREQUENCY RANGE (GHz)	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP1835-12	1-2	0.5 dB	1.5:1	15	0.5
FP1835-24	2-4	0.6 dB	1.5:1	15	0.5
FP1835-48	4-8	0.7 dB	1.6:1	14	0.6





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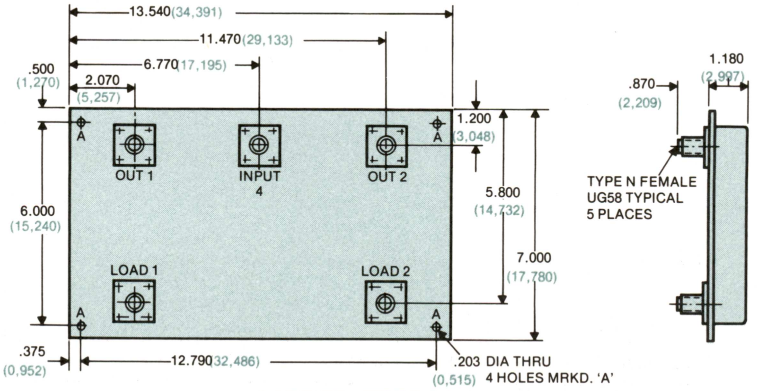
ISOLATED OUTPUT EQUAL POWER DIVIDERS

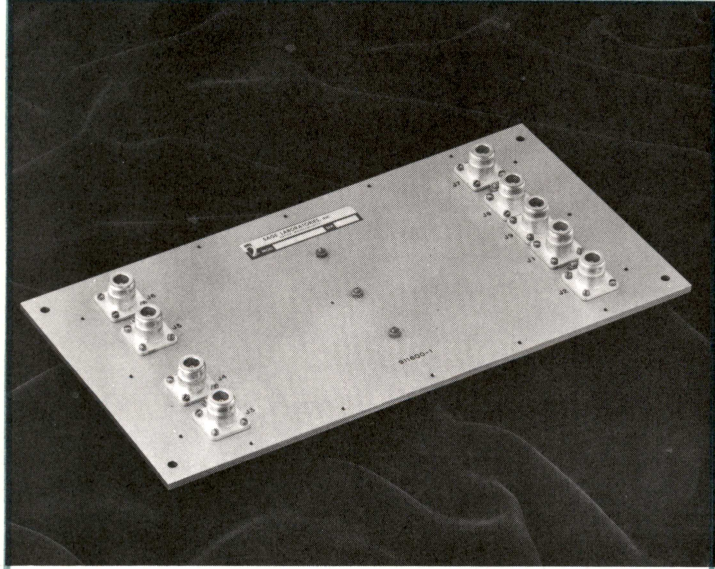
HIGH POWER UNITS FOR 420-450 MHz COMMUNICATIONS BAND

FEATURES

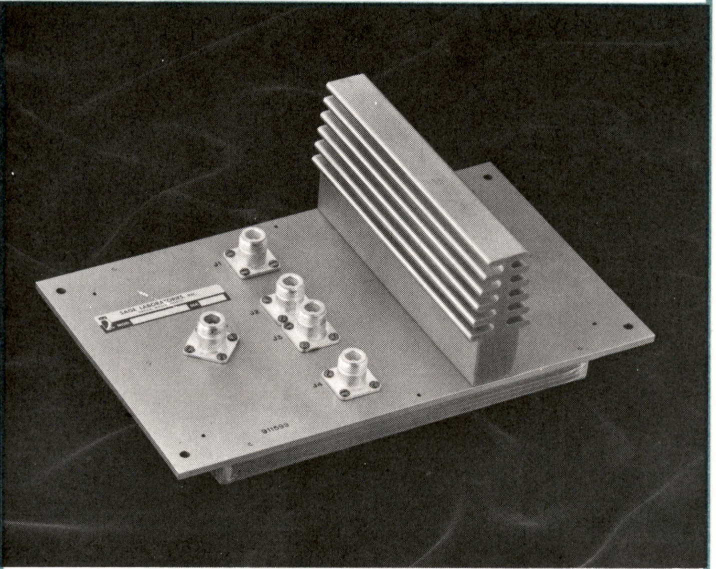
This family of high power equal dividers comprises three models which can be used individually, or can be cascaded to divide a 200-watt signal 64 ways. The units will withstand open or short circuits on any or all outputs with no damage, even when operated at full rated input power. Output phase and amplitude balance are held to tight tolerances.


13.540(34,391)
11.470(29,133)
6.770(17,195)
.500
(1,270)
2.070
(5,257)
1.180
(2,997)
.870
(2,209)
1.200
(3,048)
A
OUT 1
INPUT
4
OUT 2
5.800
(14,732)
TYPE N FEMALE
UG58 TYPICAL
5 PLACES
6.000
(15,240)
7.000
(17,780)
LOAD 1
LOAD 2
.375
(0,952)
12.790(32,486)
.203 DIA THRU
(0,515) 4 HOLES MRKD. 'A'

MODEL FP2066-1



MODEL FP2066-2

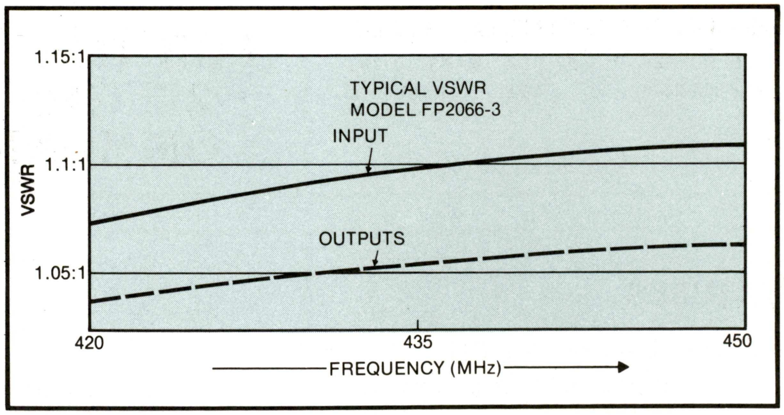


MODEL FP2066-3

MODEL NUMBER	POWER DIVISION	LENGTH		WIDTH		HEIGHT	
		INCHES	(CM)	INCHES	(CM)	INCHES	(CM)
FP2066-1	2-way	13.5	(34,290)	7.00	(17,780)	1.18	(2,997)
FP2066-2	8-way	13.5	(34,290)	7.00	(17,780)	1.18	(2,997)
FP2066-3	4-way	11.5	(29,210)	7.00	(17,780)	1.18*	(2,997)*

*With heat sink shown in photo, height is 4.44 inches (11,278 cm)

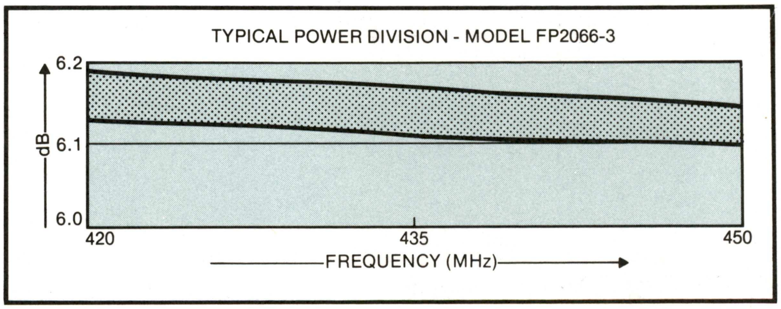
420-450 MHz HIGH POWER DIVIDERS - ELECTRICAL SPECIFICATIONS

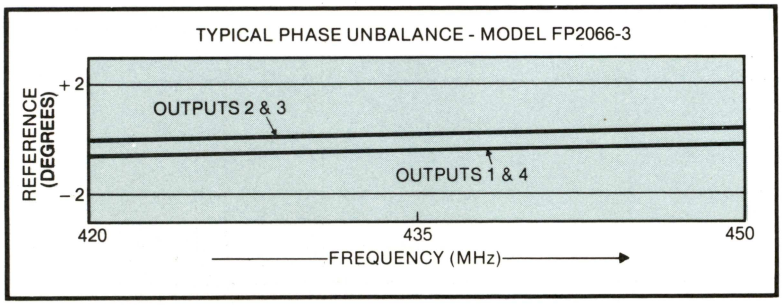


MODEL NUMBER	POWER DIVISION	AVERAGE POWER DISSIPATION (WATTS)	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR INPUT	MAXIMUM VSWR OUTPUT	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP2066-1	2-way	200*	0.2 dB	1.15	1.15	25	0.1
FP2066-2	8-way	20	0.2 dB	1.15	1.10	20	0.2
FP2066-3	4-way	100	0.2 dB	1.15	1.15	25	0.1

*Two external 50-ohm 100-watt terminations not included

The power dissipation rating of the 2-way and 4-way units can be increased to the kilowatt region throught the addition of suitable external terminations.





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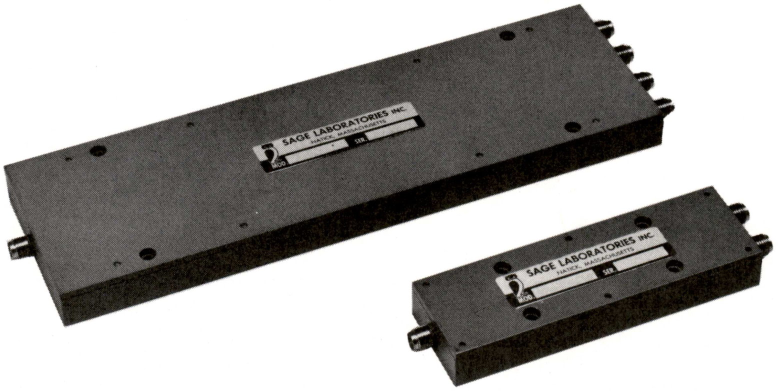
ISOLATED OUTPUT EQUAL POWER DIVIDERS

FOR THE 1-2.6 GHz COMMUNICATIONS BAND

FEATURES

- all models cover 1-2.6 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- passivated stainless steel connectors with interface per MIL-C-39012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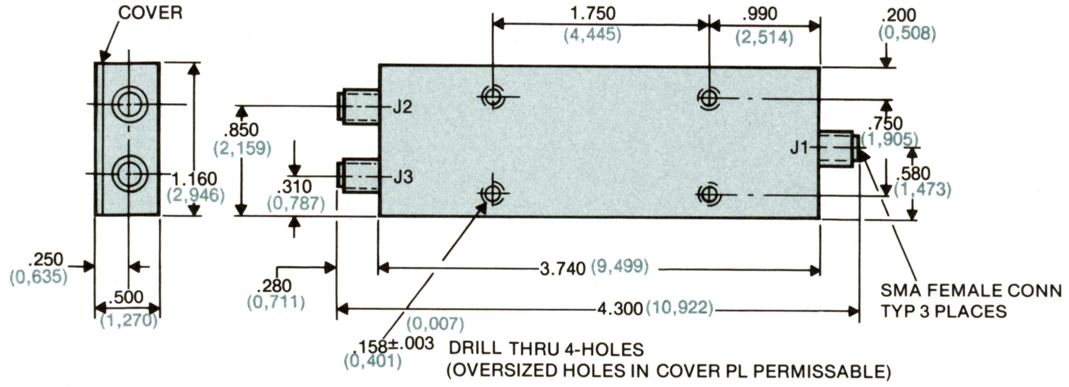
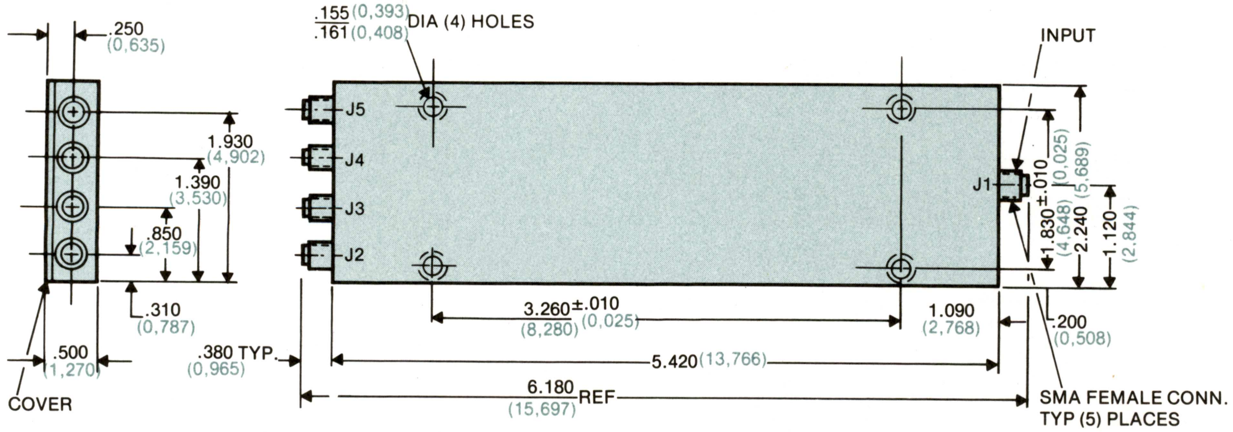
NATICK, MASSACHUSETTS
SAGE LABORATORIES INC.
NATICK, MASSACHUSETTS

(4-WAY MODELS NOW SHORTER THAN UNIT SHOWN IN PHOTO ... SEE DRAWING)

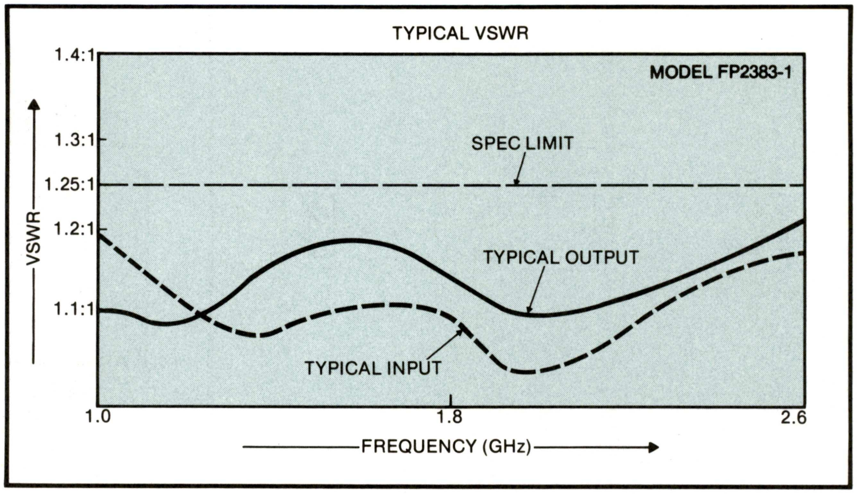
MECHANICAL DATA - MODEL FP2383-1 (2-WAY DIVIDER)


COVER
1.750
(4,445)
.990
(2,514)
.200
(0,508)
J2
J3
J1
.850
(2,159)
.310
(0,787)
1.160
(2,946)
.750
(1,905)
.580
(1,473)
.250
(0,635)
.500
(1,270)
.280
(0,711)
3.740 (9,499)
4.300 (10,922)
SMA FEMALE CONN
TYP 3 PLACES
(0,007)
.158±.003
(0,401)
DRILL THRU 4-HOLES
(OVERSIZED HOLES IN COVER PL PERMISSABLE)

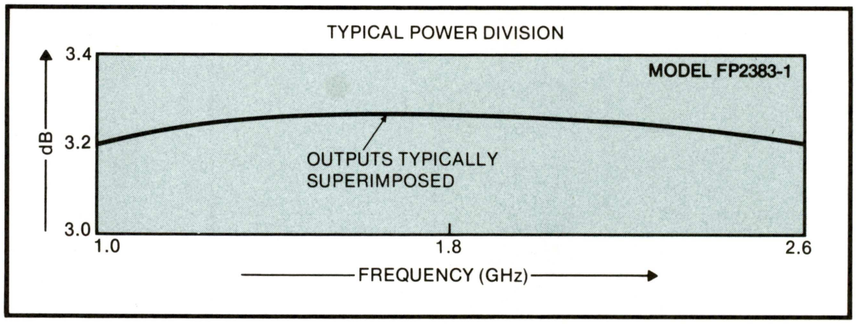
MECHANICAL DATA - MODEL FP2383-2 (4-WAY DIVIDER)

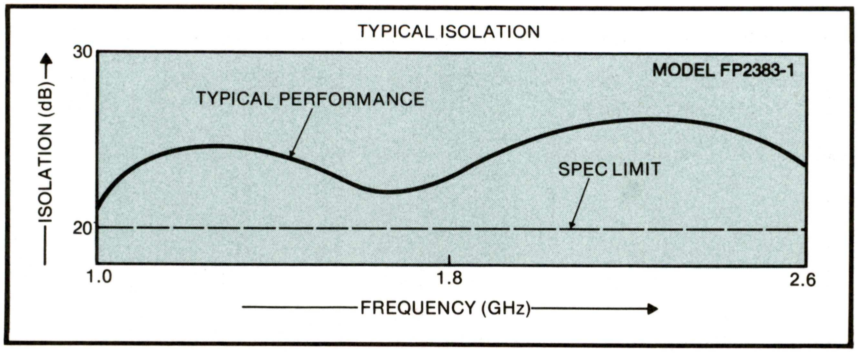

.250
(0,635)
.155 (0,393)
.161 (0,408)
DIA (4) HOLES
INPUT
J5
J4
J3
J2
J1
1.930
(4,902)
1.390
(3,530)
.850
(2,159)
.310
(0,787)
.500
(1,270)
COVER
.380 TYP.
(0,965)
1.830±.010
(4,648) (0,025)
2.240
(5,689)
1.120
(2,844)
3.260±.010
(8,280) (0,025)
1.090
(2,768)
.200
(0,508)
5.420 (13,766)
6.180 REF
(15,697)
SMA FEMALE CONN.
TYP (5) PLACES

1-2.6 GHz COMMUNICATIONS BAND POWER DIVIDERS ELECTRICAL SPECIFICATIONS



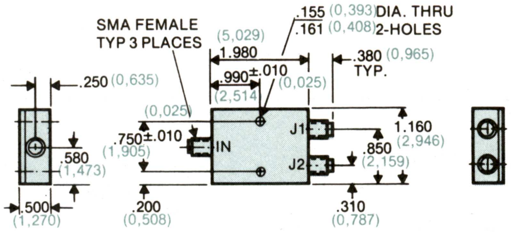
MODEL NUMBER	POWER DIVISION	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR INPUT	MAXIMUM VSWR OUTPUT	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP2383-1	2-WAY	0.4 dB	1.25	1.25	20	0.2
FP2383-2	4-WAY	0.6 dB	1.50	1.40	20	0.3



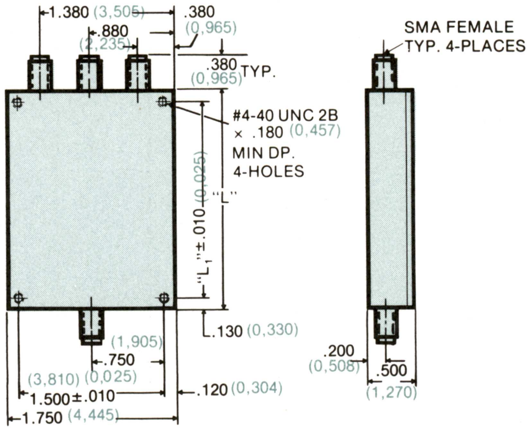


ISOLATED OUTPUT EQUAL POWER DIVIDERS

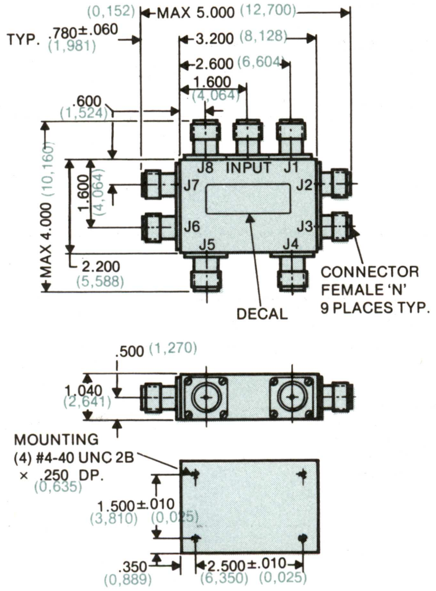
2-WAY SMA - MODEL FP2380-1

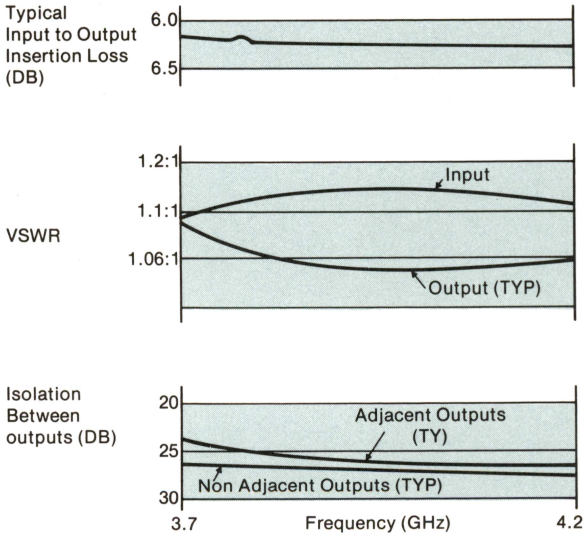

SMA FEMALE
TYP 3 PLACES
.155 (0,393) DIA. THRU
.161 (0,408) 2-HOLES
(5,029)
1.980
.990±.010
(2,514)
(0,025)
.380 (0,965)
TYP.
.250 (0,635)
(0,025)
.750±.010
(1,905)
IN
J1
J2
1.160
(2,946)
.850
(2,159)
.580
(1,473)
.500
(1,270)
.200
(0,508)
.310
(0,787)

3-WAY SMA - MODEL FP2380-2


1.380 (3,505)
.380
(0,965)
.880
(2,235)
.380
(0,965) TYP.
SMA FEMALE
TYP. 4-PLACES
#4-40 UNC 2B
× .180 (0,457)
MIN DP.
4-HOLES
"L₁" ±.010 (0,025)
"L"
.130 (0,330)
(1,905)
.750
(3,810) (0,025)
1.500±.010
1.750 (4,445)
.120 (0,304)
.200
(0,508)
.500
(1,270)

8-WAY TYPE N - MODEL FP2381-2


(0,152)
MAX 5.000 (12,700)
TYP. .780±.060
(1,981)
3.200 (8,128)
2.600 (6,604)
1.600
(4,064)
.600
(1,524)
MAX 4.000 (10,160)
1.600
(4,064)
J8 INPUT J1
J7
J2
J6
J3
J5
J4
2.200
(5,588)
DECAL
CONNECTOR
FEMALE 'N'
9 PLACES TYP.
.500 (1,270)
1.040
(2,641)
MOUNTING
(4) #4-40 UNC 2B
× .250 DP.
(0,635)
1.500±.010
(3,810) (0,025)
.350
(0,889)
2.500±.010
(6,350) (0,025)

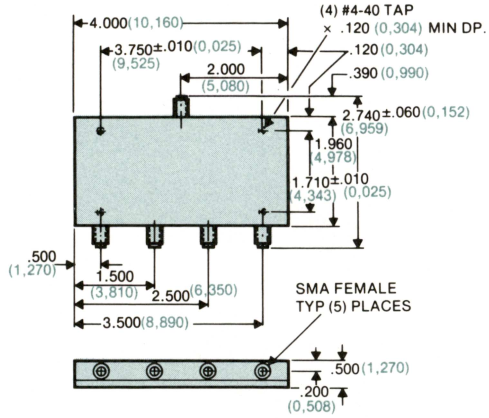


Three transformer-section 4-way power dividers.

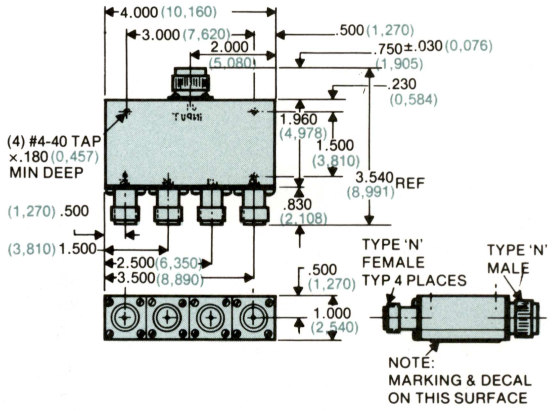
MODEL NUMBER	POWER DIVISION	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR INPUT	MAXIMUM VSWR OUTPUT	MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
FP2380-1	2-WAY	0.4 dB	1.25	1.30	20	0.2
FP2380-2	3-WAY	0.4 dB	1.40	1.40	19	0.3
FP2380-3	4-WAY	0.3 dB	1.20	1.20	20	0.2
FP2380-4	16-WAY	1.8 dB	1.50	1.25	20	0.7
FP2380-5	32-WAY	2.5 dB	1.25	1.25	18	1.0
FP2381-1	4-WAY	0.3 dB	1.20	1.20	20	0.2
FP2381-2	8-WAY	0.6 dB	1.25	1.25	25	0.6

FOR THE 3.7-4.2 GHz COMMUNICATIONS BAND

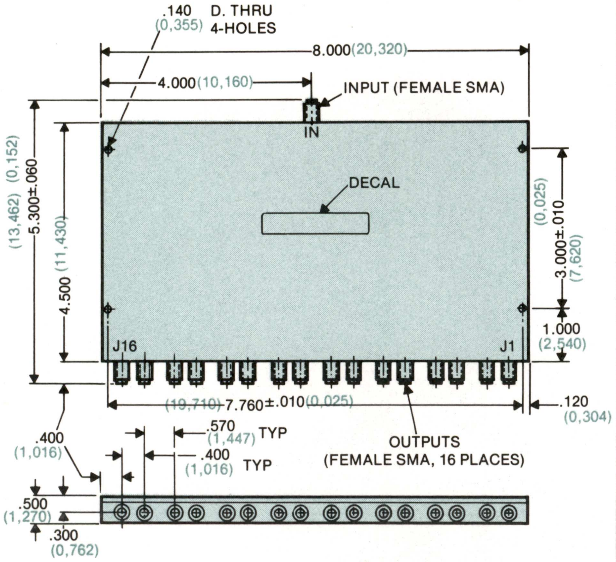
4-WAY SMA - MODEL FP2380-3


4.000(10,160)
3.750±.010(0,025)
(9,525)
2.000
(5,080)
(4) #4-40 TAP
× .120 (0,304) MIN DP.
.120 (0,304)
.390 (0,990)
2.740±.060(0,152)
(6,959)
1.960
(4,978)
1.710±.010
(4,343) (0,025)
.500
(1,270)
1.500
(3,810)
2.500(6,350)
3.500(8,890)
SMA FEMALE
TYP (5) PLACES
.500(1,270)
.200
(0,508)

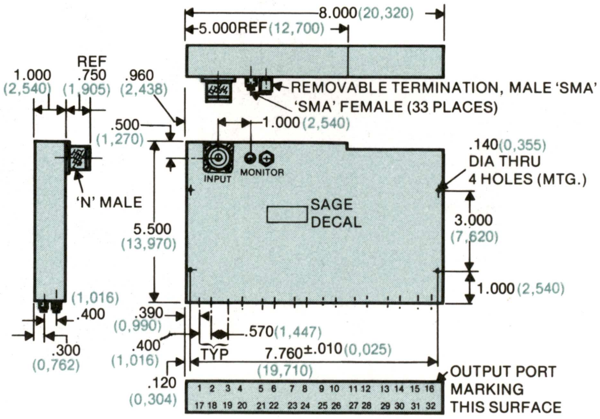
4-WAY TYPE N - MODEL FP2381-1


4.000 (10,160)
3.000 (7,620)
2.000
(5,080)
.500 (1,270)
.750±.030 (0,076)
(1,905)
.230
(0,584)
(4) #4-40 TAP
×.180 (0,457)
MIN DEEP
1.960
(4,978)
1.500
(3,810)
3.540 REF
(8,991)
.830
(2,108)
(1,270) .500
(3,810) 1.500
2.500(6,350)
3.500(8,890)
TYPE 'N'
FEMALE
TYP 4 PLACES
TYPE 'N'
MALE
.500
(1,270)
1.000
(2,540)
NOTE:
MARKING & DECAL
ON THIS SURFACE

16-WAY SMA - MODEL FP2380-4


.140 D. THRU
(0,355) 4-HOLES
8.000(20,320)
4.000(10,160)
INPUT (FEMALE SMA)
IN
DECAL
(13,462) (0,152)
5.300±.060
(11,430)
4.500
(0,025)
3.000±.010
(7,620)
1.000
(2,540)
J16
J1
(19,710) 7.760±.010(0,025)
.120
(0,304)
.570
(1,447) TYP
.400
(1,016) TYP
.400
(1,016)
OUTPUTS
(FEMALE SMA, 16 PLACES)
.500
(1,270)
.300
(0,762)

32-WAY SMA - MODEL FP2380-5


8.000(20,320)
5.000REF(12,700)
1.000
(2,540)
REF
.750
(1,905)
.960
(2,438)
REMOVABLE TERMINATION, MALE 'SMA'
'SMA' FEMALE (33 PLACES)
.500
(1,270)
1.000(2,540)
INPUT
MONITOR
'N' MALE
.140(0,355)
DIA THRU
4 HOLES (MTG.)
SAGE
DECAL
5.500
(13,970)
3.000
(7,620)
1.000(2,540)
(1,016)
.400
.300
(0,762)
.390
(0,990)
.400
(1,016)
.570(1,447)
TYP
7.760±.010(0,025)
(19,710)
.120
(0,304)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
OUTPUT PORT
MARKING
THIS SURFACE

CONNECTOR TYPE	REMARKS	MODEL NUMBER
FEMALE SMA	In-phase outputs	FP2380-1
FEMALE SMA	Offset output phase - can be equalized with mating cables	FP2380-2
FEMALE SMA	Offset output phase; in-phase outputs available	FP2380-3
FEMALE SMA	In-phase outputs	FP2380-4
FEMALE SMA	Type N input (auxiliary 20-dB coupler at input); in-phase outputs	FP2380-5
TYPE N	Type N equivalent of FP2380-3; male in, female outputs	FP2381-1
TYPE N	In-phase outputs	FP2381-2

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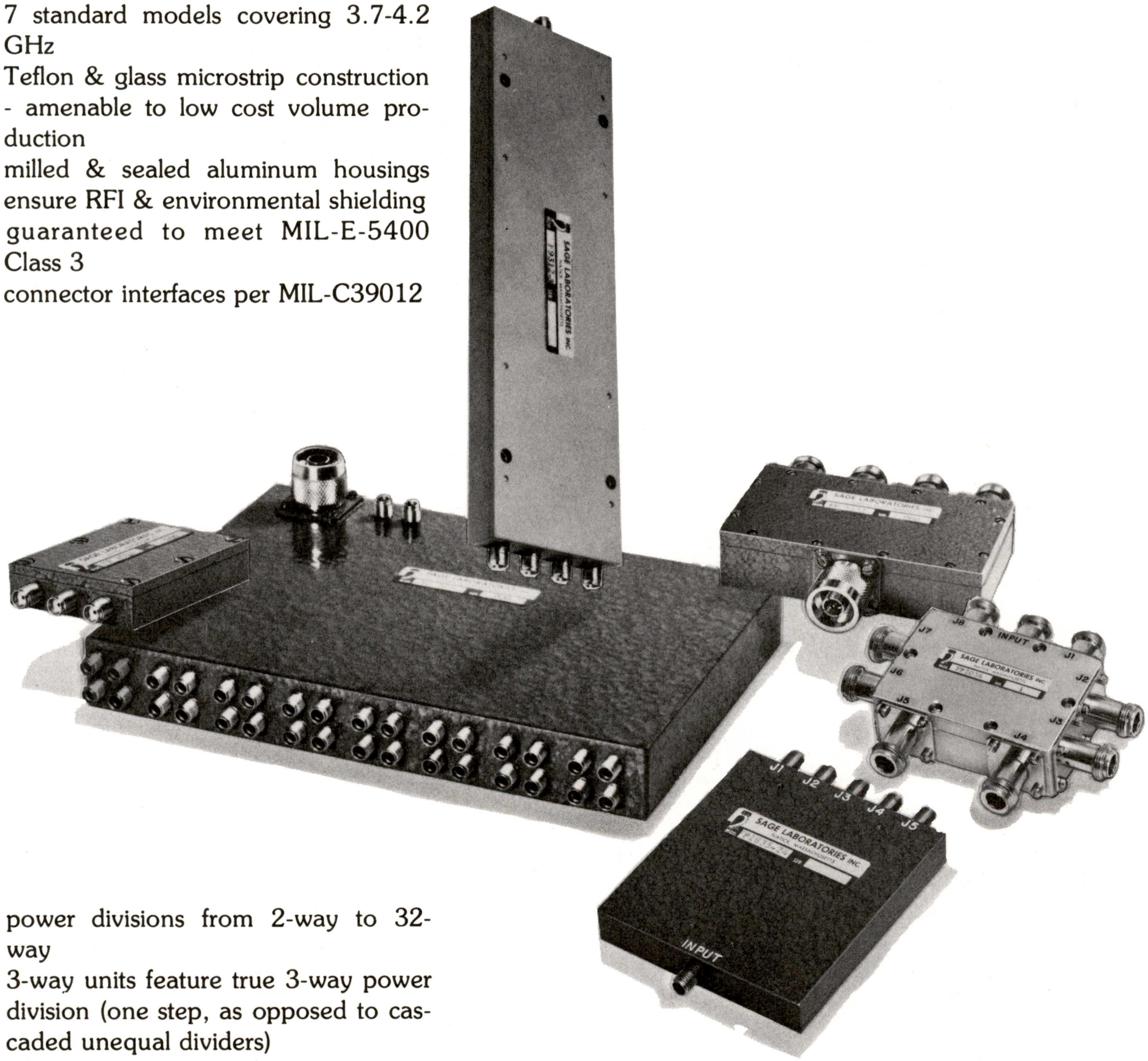
ISOLATED OUTPUT EQUAL POWER DIVIDERS FOR THE 3.7-4.2 GHz COMMUNICATIONS BAND

FEATURES

- 7 standard models covering 3.7-4.2 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- connector interfaces per MIL-C39012



- power divisions from 2-way to 32-way
- 3-way units feature true 3-way power division (one step, as opposed to cascaded unequal dividers)

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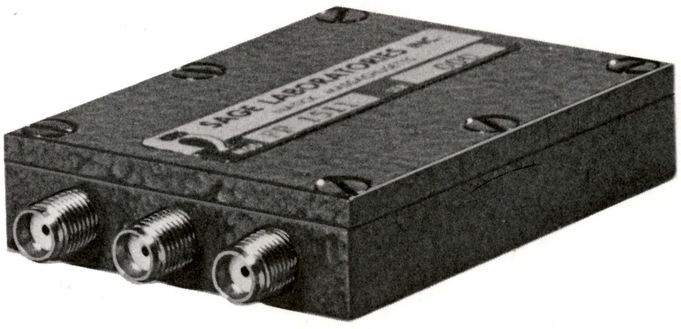
ISOLATED OUTPUT EQUAL POWER DIVIDERS

FOR THE 4.4-5.0 GHz COMMUNICATIONS BAND

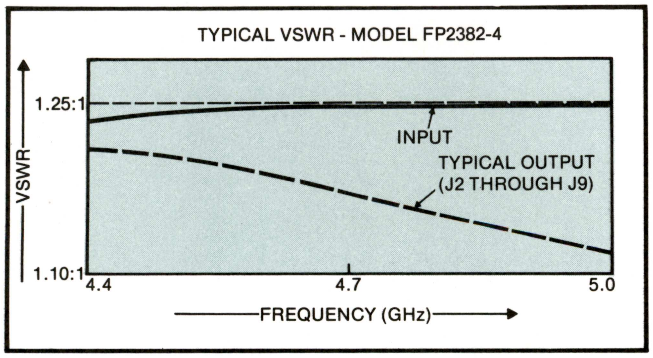
FEATURES

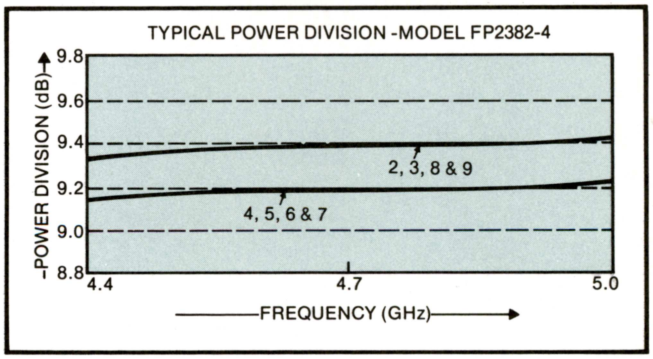
- all models cover 4.4-5.0 GHz
- Teflon & glass microstrip construction - amenable to low cost volume production
- milled & sealed aluminum housings ensure RFI & environmental shielding
- guaranteed to meet MIL-E-5400 Class 3
- passivated stainless steel connectors with interface per MIL-C-39012



ACTUAL SIZE

ELECTRICAL SPECIFICATIONS

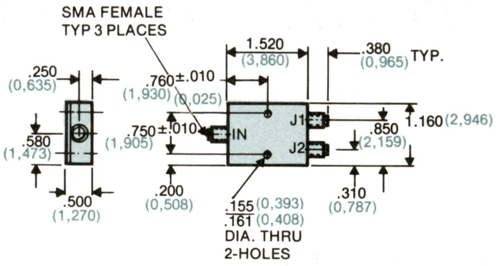

TYPICAL VSWR - MODEL FP2382-4


TYPICAL POWER DIVISION -MODEL FP2382-4

MODEL NUMBER	POWER DIVISION	MAXIMUM INSERTION LOSS (EXCLUDING POWER DIVISION LOSS)	MAXIMUM VSWR		MINIMUM ISOLATION (dB)	MAXIMUM UNBALANCE (dB)
			INPUT	OUTPUT		
FP2382-1	2-WAY	0.5 dB	1.35	1.40	20	0.3
FP2382-2	3-WAY	0.5 dB	1.40	1.40	20	0.5
FP2382-3	5-WAY	0.6 dB	1.50	1.50	15	0.6
FP2382-4	8-WAY	0.6 dB	1.25	1.25	20	0.3

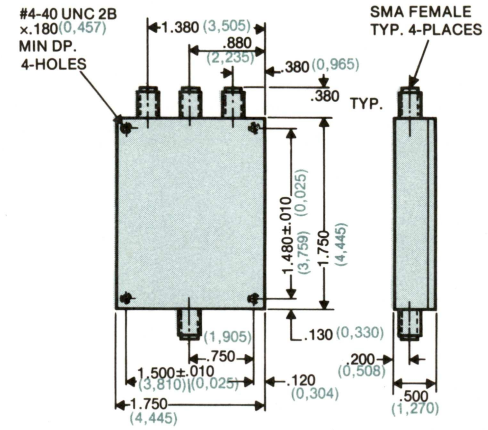
4.4-5.0 GHz COMMUNICATIONS BAND POWER DIVIDERS
MECHANICAL DATA

2-WAY - MODEL FP2382-1



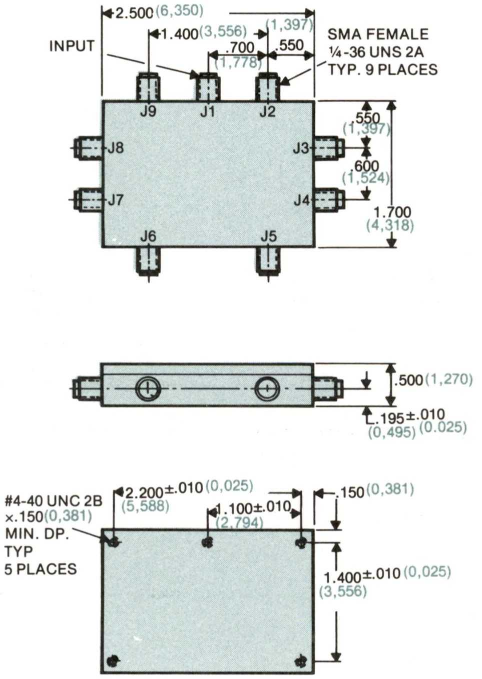
SMA FEMALE
TYP 3 PLACES
.250
(0,635)
.580
(1,473)
.500
(1,270)
.760±.010
(1,930) (0,025)
.750±.010
(1,905)
.200
(0,508)
1.520
(3,860)
IN
J1
J2
.380
(0,965)
TYP.
1.160 (2,946)
.850
(2,159)
.310
(0,787)
.155 (0,393)
.161 (0,408)
DIA. THRU
2-HOLES

3-WAY - MODEL FP2382-2



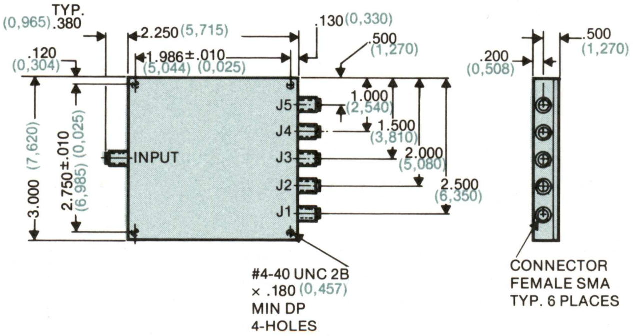
#4-40 UNC 2B
×.180(0,457)
MIN DP.
4-HOLES
1.380 (3,505)
.880
(2,235)
.380 (0,965)
.380
TYP.
SMA FEMALE
TYP. 4-PLACES
1.480±.010
(3,759) (0,025)
1.750
(4,445)
(1,905)
.750
1.500±.010
(3,810) (0,025)
.130 (0,330)
.120
(0,304)
1.750
(4,445)
.200
(0,508)
.500
(1,270)

8-WAY - MODEL FP2382-4



INPUT
2.500 (6,350)
1.400 (3,556)
(1,397)
.700
(1,778)
.550
SMA FEMALE
¼-36 UNS 2A
TYP. 9 PLACES
J9
J1
J2
J8
J3
J7
J4
J6
J5
.550
(1,397)
.600
(1,524)
1.700
(4,318)
.500 (1,270)
.195±.010
(0,495) (0.025)
#4-40 UNC 2B
×.150 (0,381)
MIN. DP.
TYP
5 PLACES
2.200±.010 (0,025)
(5,588)
1.100±.010
(2,794)
.150 (0,381)
1.400±.010 (0,025)
(3,556)

5-WAY - MODEL FP2382-3



TYP.
(0,965) .380
.120
(0,304)
2.250 (5,715)
1.986±.010
(5,044) (0,025)
.130 (0,330)
.500
(1,270)
3.000 (7,620)
2.750±.010
(6,985) (0,025)
INPUT
J5
J4
J3
J2
J1
1.000
(2,540)
1.500
(3,810)
2.000
(5,080)
2.500
(6,350)
#4-40 UNC 2B
× .180 (0,457)
MIN DP
4-HOLES
.200
(0,508)
.500
(1,270)
CONNECTOR
FEMALE SMA
TYP. 6 PLACES

MATERIALS & FINISHES

Housings: machined aluminum

Sealing: epoxy

Finish: green hammertone (Sage)

Connectors: SMA female (standard), passivated stainless steel shells, interfaces per MIL-C-39012

Alternative connectors, materials & finishes on special order

sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

HYBRIDS AND COUPLERS

CONTENTS OF THIS SECTION PAGE

A Guide to Hybrid & Coupler Selection **155-157**
Custom Engineering Capabilities **158-165**
Standard Products **166-201**
Application Notes **202-210**

A GUIDE TO HYBRID & COUPLER SELECTION

In two matrices, we show the various types of hybrids and couplers manufactured by Sage, and compare their functions and relative merits. The matrices will help you to select one of our standard models which will meet your needs. Should you require a special unit, our engineers will design one to meet your specific needs. This can often be done by modifying a standard catalog design at nominal extra cost. The section following this selection guide shows a number of specific examples of our capabilities in custom engineered hybrids and couplers. Your engineering inquiries are cordially invited.

HYBRID SELECTION MATRIX	**WIRELINE**	**700 SERIES COBRID HIGH POWER QUADRATURE HYBRIDS**	**748 SERIES TEMLINE HIGH POWER QUADRATURE HYBRIDS**	**D750/DC750 SERIES MINIATURE OCTAVE-BAND HYBRIDS**	**2375 SERIES MINIATURE MULTI-OCTAVE HYBRIDS**
Lowest Cost	X				
Octave-Band	X		X	X	
Multi-Octave Band					X
Frequency Range of Series (GHz)	to 2	.96-12	.06-12	.5-18	.5-18
Highest Power		X	X		
Standard Connectors	None	N/TNC	N	SMA	SMA

A GUIDE TO HYBRID & COUPLER SELECTION (Continued)

Hybrids. The basic function of a hybrid is to provide a nominally equal power division to two output ports from either of two input ports. The two inputs are isolated from each other if the outputs are terminated in matched loads.

Hybrids are grouped into two main categories ... (1) units whose outputs are in phase quadrature (90° phase difference) ... (2) units (magic tee) whose outputs are in phase when fed from one input, and out of phase when fed from the other input. Although Sage manufactures some magic tees (see Custom Engineering Capabilities, next section), the standard products shown in this catalog are all of the quadrature type.

NOTE. Power Dividers, shown in a separate section of this catalog, are equivalent to magic tee units with the out-of-phase (Δ) feed ports terminated internally.

Quadrature hybrids with integral terminations on one of their inputs are listed in the coupler portion of this catalog section. These units are available with inputs and outputs on opposing sides for convenient interconnection.

WIRELINE^{TM} provides the most cost-effective approach where hybrids with bandwidths of an octave or less are required. Generally, an upper frequency limit of approximately 1200 MHz is dictated for WIRELINE, simply because the lengths become so short that handling and assembly are difficult. At the lower end of the WIRELINE frequency range, power is the limiting factor (100 watts maximum average power at 300 MHz & 25°C). Bear in mind, however, that in requirements where the quantity is sufficient to cost-justify some special handling, we can supply specially assembled WIRELINE units which will provide higher power handling capability and higher frequency coverage. We suggest that you discuss the matter with our engineers.

Sage printed circuit stripline hybrid assemblies provide a cost-effective approach for higher frequency units (to 18 GHz standard) in both single-octave and multi-octave coverage. Our standard octave-band units include "split band" coverage of the popular communications bands. **NOTE.** If you can achieve your desired frequency coverage with an octave-band unit, you will find it preferable to do so. The increased circuit complexity required for multi-octave band units increases unit cost.

For power levels too high for printed circuit units, we recommend our TEMLINE hybrids, which provide larger cross-sections with silver-brazed center conductors. If power is a major consideration, the increased cost of TEMLINE units is justifiable.

COBRIDS are large cross-section devices which use coalesced branch-line coupling to provide quadrature hybrid performance. Their major attribute is power handling capability. COBRID bandwidth is less than that of TEMLINE units for a given unbalance, and the phase of a COBRID device varies from 90 degrees across the passband.

Couplers. As with quadrature hybrids, coupler selection criteria should be based on your power and frequency coverage requirements. **NOTE.** In all cases, the coupler's main line will carry more power than can be dissipated in the integral termination on the coupled line. With weak coupling, however, the power level reaching the termination is only a small fraction of the main line power. If, after reviewing our standard couplers, you find that the power rating of the integral termination is insufficient for your purposes, contact our Sale Department. We can supply couplers with the terminations replaced by connectors, to which suitable loads can be attached. In the case of our 7800 and D750 series, the terminations are screwed on; you can replace them easily if they are ever damaged or if you require a larger load.

For narrowband, low frequency, moderate power applications we recommend WIRELINE as your most cost-effective approach to your coupler needs.

A GUIDE TO HYBRID & COUPLER SELECTION (Continued)

For moderate power octave-band and multi-octave band applications to 18 GHz, we refer you to our extensive line of stripline miniature couplers. Standard coupling values range from 3 dB to 20 dB. (The 7901 series of communications band couplers range as high as 50 dB.) These units are available in *H-style* and *in-line* configurations. Construction techniques, circuit designs, and electrical specifications for the two configurations are similar. The only major differences lie in the mechanical configurations.

For higher power operation (to the limits of type N connectors), we recommend our series 7800 or 783 units (20-dB and 30-dB coupling) and 748-3 series units (3-dB coupling).

For coupling values, frequency bands, or connector types not shown in our standard product data, we invite you to consult with our engineers. The following pages (Custom Engineering Capabilities) show a variety of units designed by Sage to meet requirements of higher power, looser coupling, special packaging, waveguide designs, etc.

COUPLER SELECTION MATRIX	**WIRELINE**	**748-3 SERIES TEMLINE HIGH POWER**	**783 SERIES OCTAVE BAND HIGH POWER**	**7800 SERIES OCTAVE BAND HIGH POWER**	**7901 SERIES COMMUNICATIONS BAND COUPLERS**	**C750 SERIES MINIATURE IN-LINE COUPLERS**	**D750 SERIES MINIATURE H-STYLE COUPLERS**	**C112 SERIES MINIATURE ULTRA BROADBAND COUPLERS**
NARROWBAND & LOWEST COST	X							
OCTAVE BANDWIDTHS		X	X	X		X	X	
COMMUNICATIONS BAND COVERAGE					X	X	X	X
MULTI-OCTAVE BANDWIDTHS								X
HIGHEST POWER		X	X	X				
FREQUENCY RANGE OF SERIES (GHz)	To 2	.06-4	2-4	.06-2	3.7-4.2	.5-18	.5-18	1-18
STANDARD COUPLING VALUES (dB)	AS REQUIRED	3	10,20,30	20,30	20,30, 40,50	6,10, 20,30	6,10, 20,30	6,10, 15,20
STANDARD CONNECTOR TYPES	NONE	N	N	N	N	SMA	SMA	SMA

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CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS

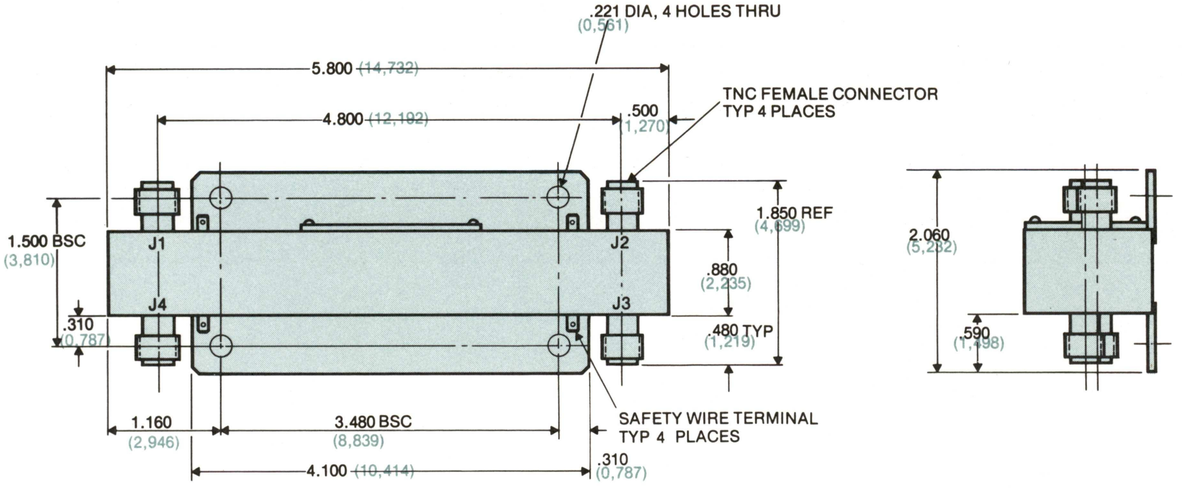
Sage Laboratories' capabilities in hybrids and couplers cover the entire microwave spectrum, and include the following major technologies.

- printed circuit etching
- WIRELINE
- machined fabrications
- coaxial and waveguide structures

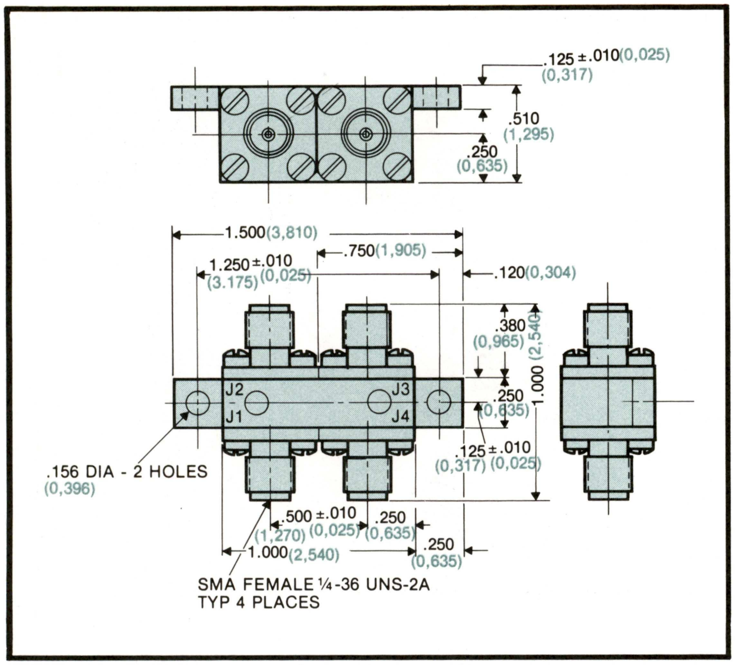
The following pages highlight selected examples of our custom engineering capabilities in these areas.

MISSILE-QUALIFIED COAXIAL HYBRID FEATURING ELECTRON-BEAM-WELDED ALUMINUM BODY

Model 750AH, shown below, was developed for a missile system. The aluminum body is sealed by means of electron beam welding. This design operates from 406-420 MHz. Coupling, including insertion loss, is 3.2±0.2 dB. VSWR is 1.3:1 maximum, and isolation is 25 dB minimum.


.221 DIA, 4 HOLES THRU
(0,561)
5.800 (14,732)
4.800 (12,192)
.500
(1,270)
TNC FEMALE CONNECTOR
TYP 4 PLACES
1.500 BSC
(3,810)
J1
J2
J4
J3
1.850 REF
(4,699)
.880
(2,235)
.310
(0,787)
.480 TYP
(1,219)
2.060
(5,232)
.590
(1,498)
1.160
(2,946)
3.480 BSC
(8,839)
SAFETY WIRE TERMINAL
TYP 4 PLACES
.310
(0,787)
4.100 (10,414)

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)



.125 ±.010(0,025)
(0,317)
.510
(1,295)
.250
(0,635)
1.500(3,810)
.750(1,905)
1.250±.010
(3.175)(0,025)
.120(0,304)
.380
(0,965)
1.000 (2,540)
J2
J3
J1
J4
.250
(0,635)
.125±.010
(0,317) (0,025)
.156 DIA - 2 HOLES
(0,396)
.500±.010
(1,270) (0,025)
.250
(0,635)
1.000(2,540)
.250
(0,635)
SMA FEMALE ¼-36 UNS-2A
TYP 4 PLACES

WIRELINE PROVIDES HIGH RELIABILITY IN SPACE HYBRIDS

Model FC1424, illustrated at left, is representative of the many space-qualified hybrids supplied by Sage. The electrical performance of the unit is as follows.

Frequency Range: 7-8 GHz

Insertion Loss: 0.3 dB maximum (0.2 dB typical)

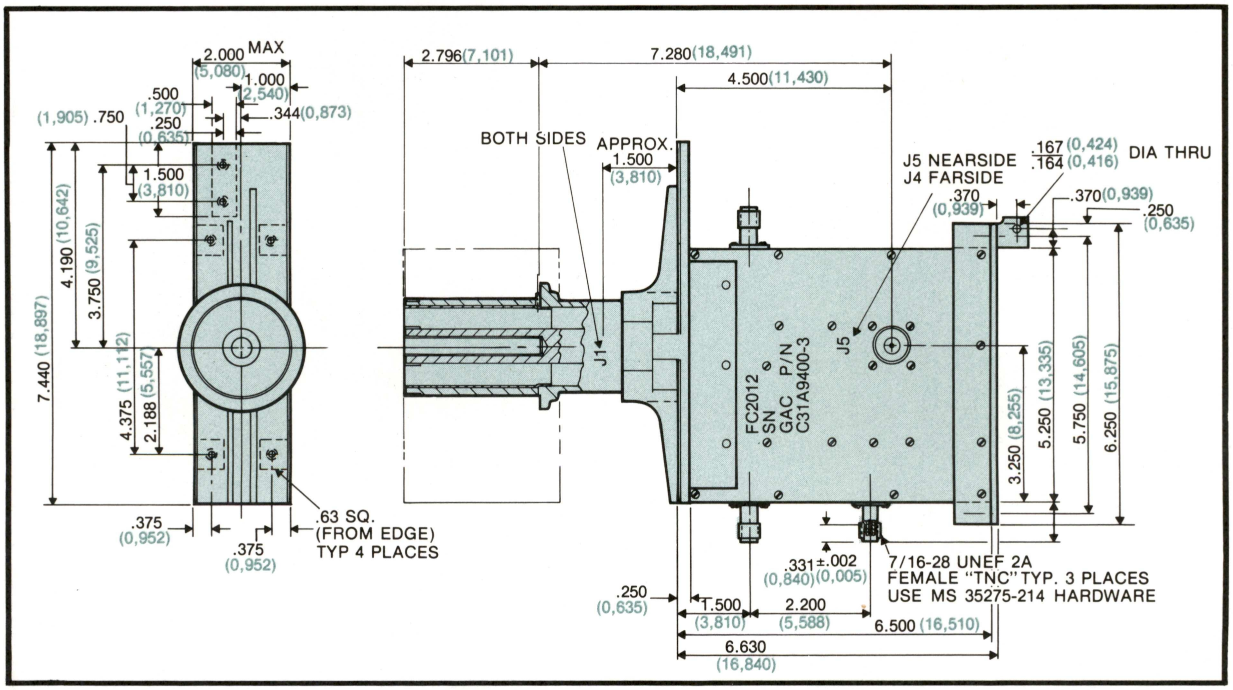
Isolation: 20 dB minimum (26 dB typical)

Unbalance: 0.6 dB maximum (0.3 dB typical)

VSWR: 1.25:1 maximum (1.10:1 typical)

This design uses WIRELINE™ construction (see separate WIRELINE section of this catalog) to maximize reliability.

MODEL FC2012 - AN EXAMPLE OF SPECIALIZED PACKAGING NEEDS MET BY SAGE



2.000 MAX
(5,080)
1.000
(2,540)
.500
(1,270)
.344(0,873)
(1,905) .750
.250
(0,635)
1.500
(3,810)
4.190 (10,642)
3.750 (9,525)
7.440 (18,897)
4.375 (11,112)
2.188 (5,557)
.375
(0,952)
.375
(0,952)
.63 SQ.
(FROM EDGE)
TYP 4 PLACES
2.796(7,101)
7.280(18,491)
4.500(11,430)
BOTH SIDES
APPROX.
1.500
(3,810)
J1
FC2012
SN
GAC P/N
C31A9400-3
J5
J5 NEARSIDE
J4 FARSIDE
.370
(0,939)
.167 (0,424)
.164 (0,416)
DIA THRU
.370(0,939)
.250
(0,635)
3.250 (8,255)
5.250 (13,335)
5.750 (14,605)
6.250 (15,875)
.331±.002
(0,840)(0,005)
7/16-28 UNEF 2A
FEMALE "TNC" TYP. 3 PLACES
USE MS 35275-214 HARDWARE
.250
(0,635)
1.500
(3,810)
2.200
(5,588)
6.500 (16,510)
6.630
(16,840)

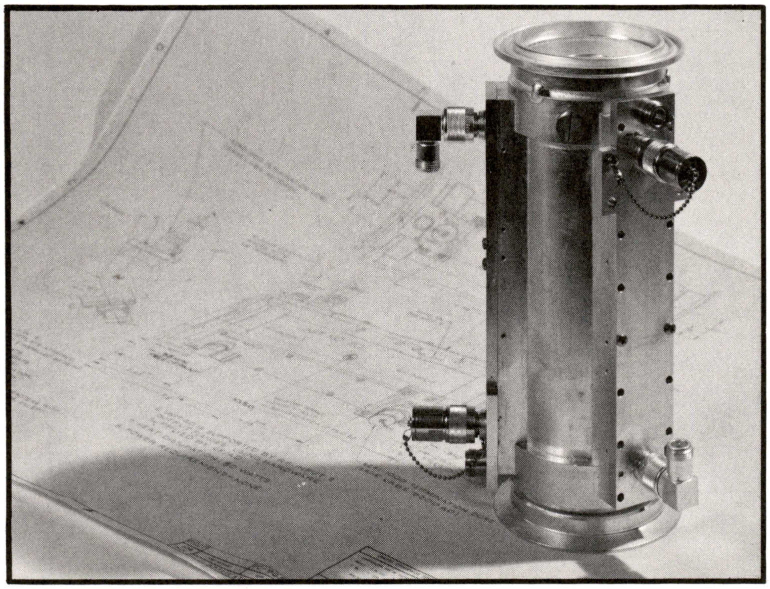
Model FC2012 was designed to meet highly specialized mechanical requirements as well as special electrical needs. The unit includes dual 8.3-dB couplers and a short delay line. The coupler is supported entirely by its special 1-5/8" coaxial input connector. In its operating environment (aircraft), the coupler supports a coaxial switch, a high power load, and a pair of antennas. This unit covers a broad frequency range.

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)

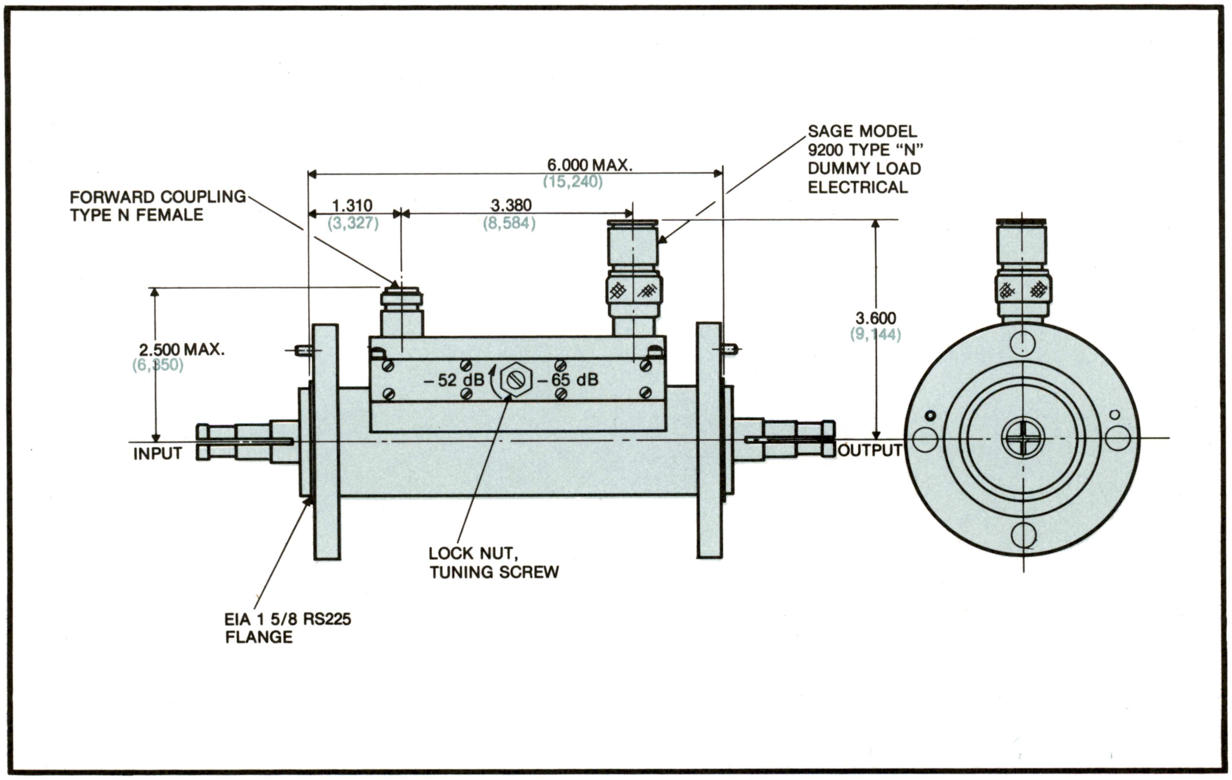
EARLY WARNING RADAR UNIT FEATURES TRACKING COUPLERS

Model FC9659A is a very high power UHF bidirectional coupler which is used in an early warning radar system. The unit contains tracking 40-dB and 50-dB couplers with minimum directivity of 35 dB and 30 dB, respectively. Coupling is held to ±0.2 dB. Main line VSWR is less than 1.05:1.

As positioned in the photograph at right, the unit is approximately 10 inches high. Weight is less than 5 pounds.



L-BAND DESIGN FEATURES SCREWDRIVER-ADJUSTABLE COUPLING



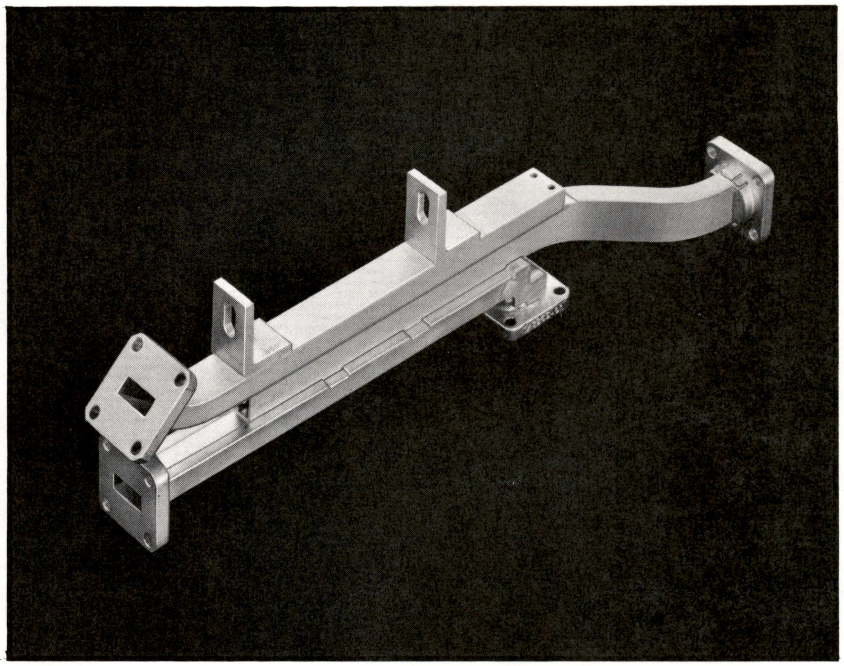
SAGE MODEL 9200 TYPE "N" DUMMY LOAD ELECTRICAL
6.000 MAX.
(15,240)
FORWARD COUPLING TYPE N FEMALE
1.310
(3,327)
3.380
(8,584)
3.600
(9,144)
2.500 MAX.
(6,350)
-52 dB
-65 dB
INPUT
OUTPUT
LOCK NUT, TUNING SCREW
EIA 1 5/8 RS225 FLANGE

Model F6094 is an L-band unit which provides fine screwdriver adjustment of coupling over a range of 52 dB to 65 dB. The main line is EIA standard 1-5/8 inch.

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)

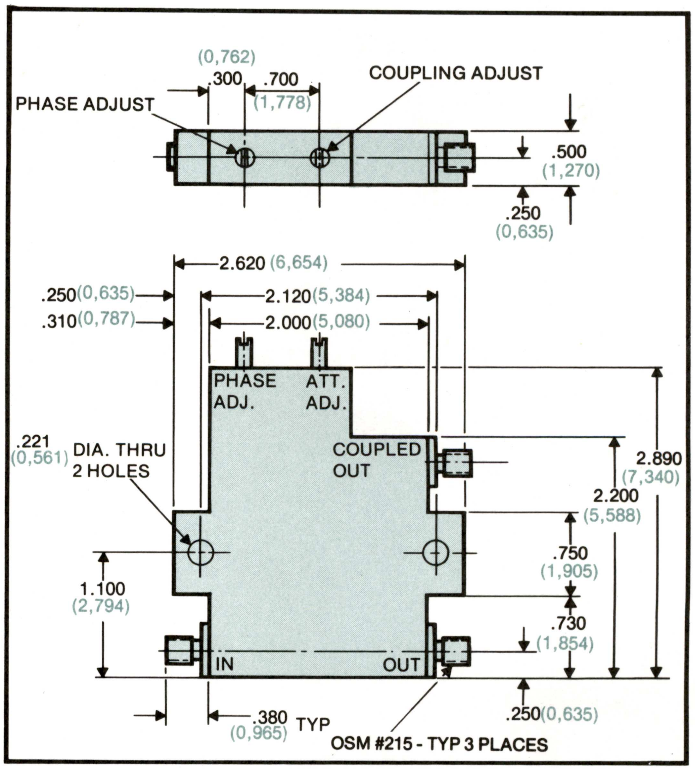
DUAL WAVEGUIDE COUPLER FOR COMMUNICATIONS SATELLITE WEIGHS ONLY 2 OUNCES

Model FC1726 is a dual directional waveguide coupler for communications satellite applications. Its operating frequency range is 17.7-21.0 GHz. Through-line insertion loss is typically less than 0.1 dB, and VSWR is typically below 1.1:1. The reverse couplers meet the configuration restraints of a particular application, providing a 25-dB test port and a 50-dB power monitor output from 17.7-21.0 GHz. The weight of the unit shown is 2 ounces.



UHF COUPLER FEATURES SCREWDRIVER ADJUSTMENT OF COUPLING & PHASE

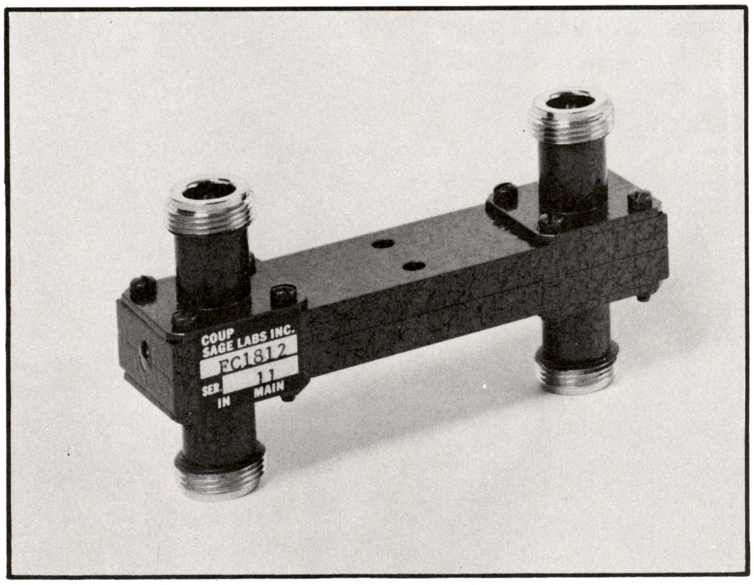
Model 780-10F operates from 290-310 MHz, and features screwdriver adjustment of coupled port phase and coupling. Coupled phase is adjustable over a 120-degree minimum range, and coupling amplitude is adjustable from 10 dB to 13 dB. Main line insertion loss of the unit is 1 dB maximum. Main line VSWR is 1.25:1 maximum. Power handling capability is 4 watts c-w.

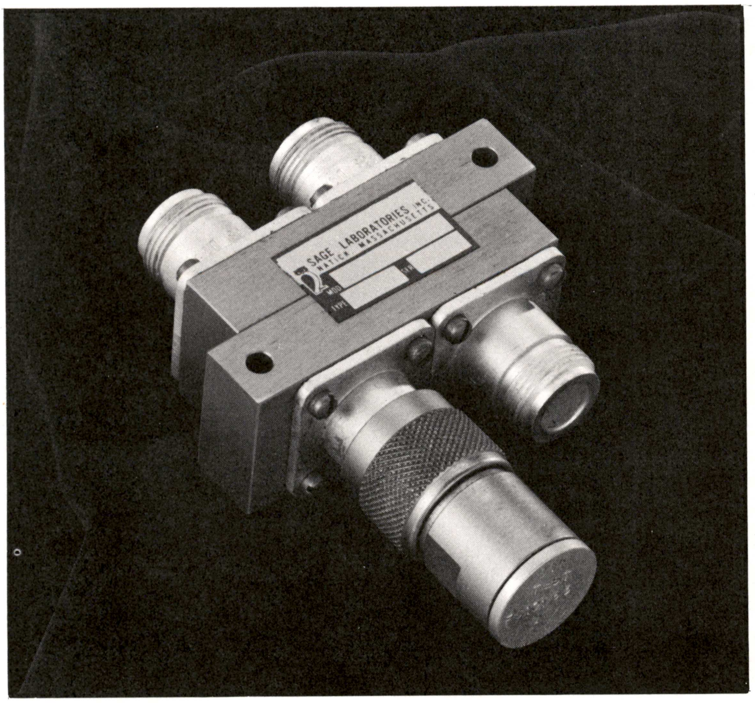

(0,762)
.300
.700
(1,778)
COUPLING ADJUST
PHASE ADJUST
.500
(1,270)
.250
(0,635)
2.620 (6,654)
.250(0,635)
.310(0,787)
2.120(5,384)
2.000(5,080)
PHASE ADJ.
ATT. ADJ.
.221
(0,561)
DIA. THRU 2 HOLES
COUPLED OUT
2.890
(7,340)
2.200
(5,588)
.750
(1,905)
1.100
(2,794)
.730
(1,854)
IN
OUT
.380
(0,965)
TYP
.250(0,635)
OSM #215 - TYP 3 PLACES

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)

LOW LOSS 200-WATT AVERAGE POWER COUPLER FEATURES WIRELINE CONSTRUCTION

Model FC1812 is a 12-dB coupler covering the frequency range of 118-136 MHz. The unit features WIRELINE construction. The input-to-output center conductor is a single piece of wire soldered directly to the type N center conductor contact at each port. This is equivalent to a piece of semi-rigid coaxial cable. The unit has no interior voids. Interior spaces near the connectors are potted with a low loss RTV silicon rubber. With this construction, there is no need for unreliable hermetically sealed connectors. Over the operational range of 118-136 MHz, coupling is held to ±1.0 dB, directivity is 20 dB minimum, and VSWR is 1.2:1 maximum. Insertion loss is 0.35 dB maximum, 0.1 dB typical (excluding coupling loss). The main line input power rating is 400 watts peak, 200 watts average.



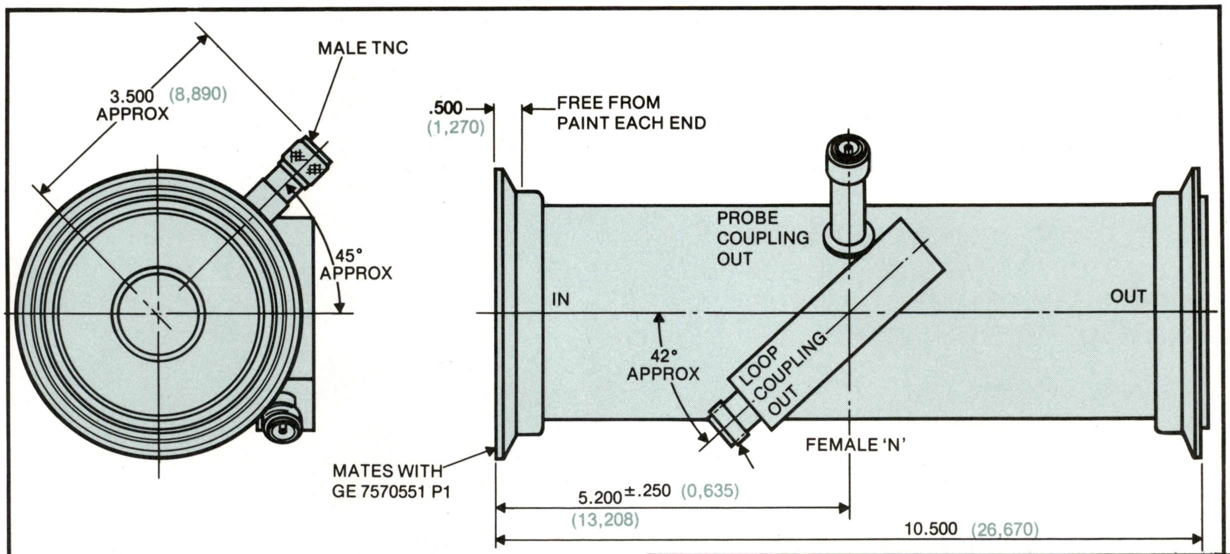


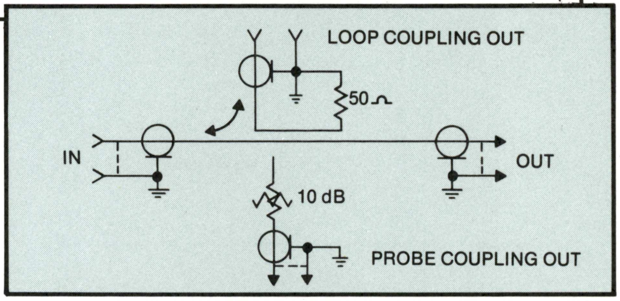
COMPACT LOW LOSS COUPLER FOR EARLY WARNING RADAR SYSTEM

Model FC2066-4 is a 30-dB coupler with an operating frequency range of 420-450 MHz. The unit uses a compact, low loss air-line coupling design. Insertion loss is 0.03 dB. VSWR is 1.04:1. Directivity is 29 dB. This unit is rated at 300 watts peak, 75 watts average power.

The configuration shown met the packaging requirements of an early warning radar system.

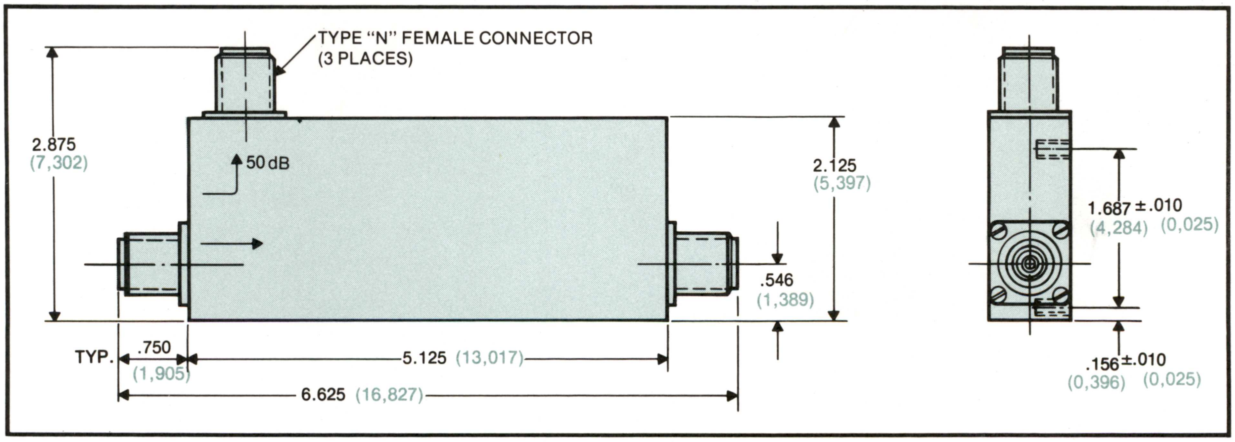
CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)


MALE TNC
3.500 (8,890) APPROX
45° APPROX
.500 (1,270)
FREE FROM PAINT EACH END
PROBE COUPLING OUT
IN
OUT
42° APPROX
LOOP COUPLING OUT
FEMALE 'N'
MATES WITH GE 7570551 P1
5.200 ±.250 (0,635) (13,208)
10.500 (26,670)


LOOP COUPLING OUT
50 Ω
IN
OUT
10 dB
PROBE COUPLING OUT

3-1/8" COAXIAL COUPLER SAMPLES SPURIOUS OUTPUTS IN UHF TRANSMITTER TO 8 GHz

Model FC1825 provides loop and probe samples for the measurement of spurious outputs from a UHF transmitter to 8 GHz. Nominal coupling varies from approximately 50 dB at 8 GHz to 75 dB at 400 MHz. Main line VSWR is less than 1.1:1 from 400-500 MHz.


TYPE "N" FEMALE CONNECTOR (3 PLACES)
2.875 (7,302)
50 dB
2.125 (5,397)
.546 (1,389)
TYP. .750 (1,905)
5.125 (13,017)
6.625 (16,827)
1.687 ±.010 (4,284) (0,025)
.156 ±.010 (0,396) (0,025)

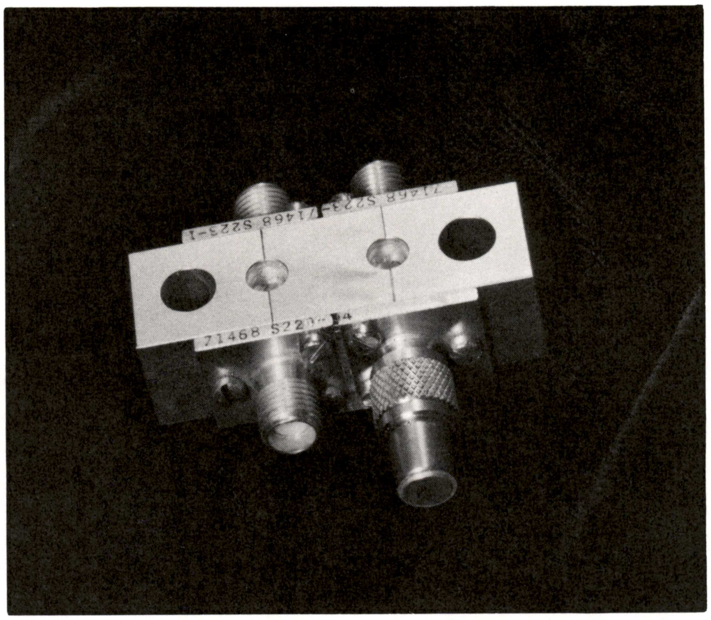
L-BAND COUPLER IS COMPACT, YET WITHSTANDS 7 KW PEAK POWER, 300 WATTS AVERAGE

Model FC10163 is a 50±0.5 dB coupler design with a typical directivity of 30 dB. Insertion loss is 0.3 dB maximum. This design is representative of conventional air-dielectric quarter-wavelength couplers designed and manufactured by Sage. These designs can easily be modified for special coupling values and other center frequencies. Power handling capability generally is limited by the connector series.

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)

WIRELINE™ CONSTRUCTION PRODUCES RUGGED 4.8-dB COUPLER FOR GIANT PATRIOT MINUTEMAN MISSILE PROGRAM

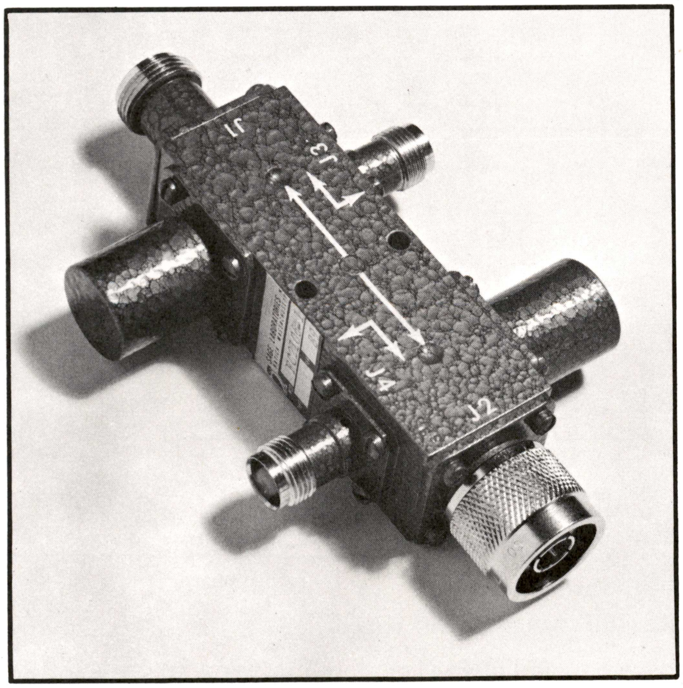
This missile-qualified 4.8-dB WIRELINE coupler is typical of a number of Sage space-qualified and missile-qualified couplers with 3-dB to 30-dB coupling over a variety of frequency ranges. The unit shown has an operating frequency range of 5.4-5.9 GHz. It can be teamed with a power divider to obtain 3-way power division.



SHOWN APPROXIMATELY ACTUAL SIZE

HIGH POWER WIRELINE™ BIDIRECTIONAL COUPLERS FOR TACAN PROGRAM

This unit uses WIRELINE construction techniques to provide reliable bidirectional 20-dB and 30-dB couplers over a frequency range of 960-1215 MHz. The normal operational power level withstood by these units is 1.5 KW peak at a 10% duty cycle. All internal voids are potted to preclude moisture entry, and to prevent corona breakdown.



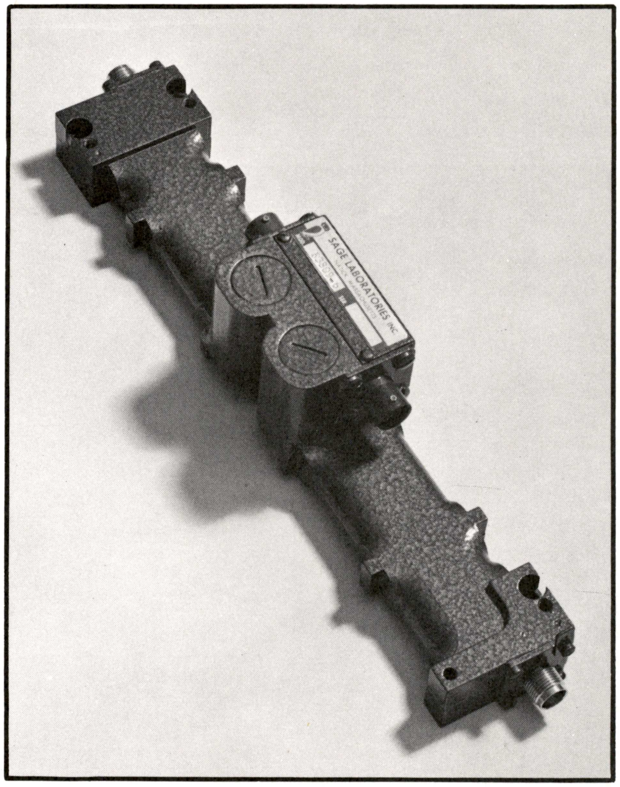
SHOWN APPROXIMATELY ACTUAL SIZE

CUSTOM ENGINEERING CAPABILITIES IN HYBRIDS & COUPLERS
(Continued)

FOR DYNASOAR, WE DEVELOPED THIS MAGNESIUM BIDIRECTIONAL COUPLER & POWER MONITOR

Model F3809-6 dramatizes our interest in meeting specific customer requirements, and is a further demonstration of our background in microwave components for space programs. This magnesium-bodied unit includes UHF bidirectional couplers and power-monitor diode detectors. These units were developed for DYNASOAR, America's first manned space flight program.

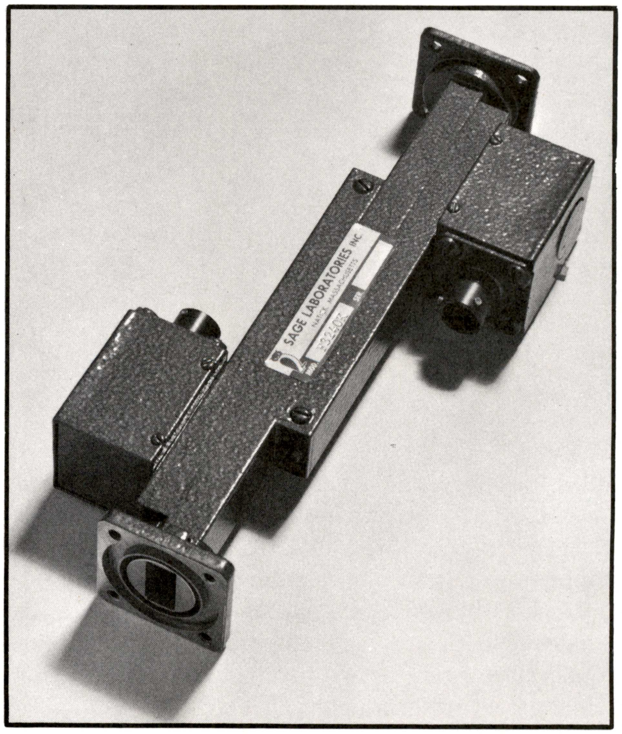
SHOWN APPROXIMATELY HALF-SIZE



THIS UNIT, TOO, WAS DEVELOPED FOR DYNASOAR

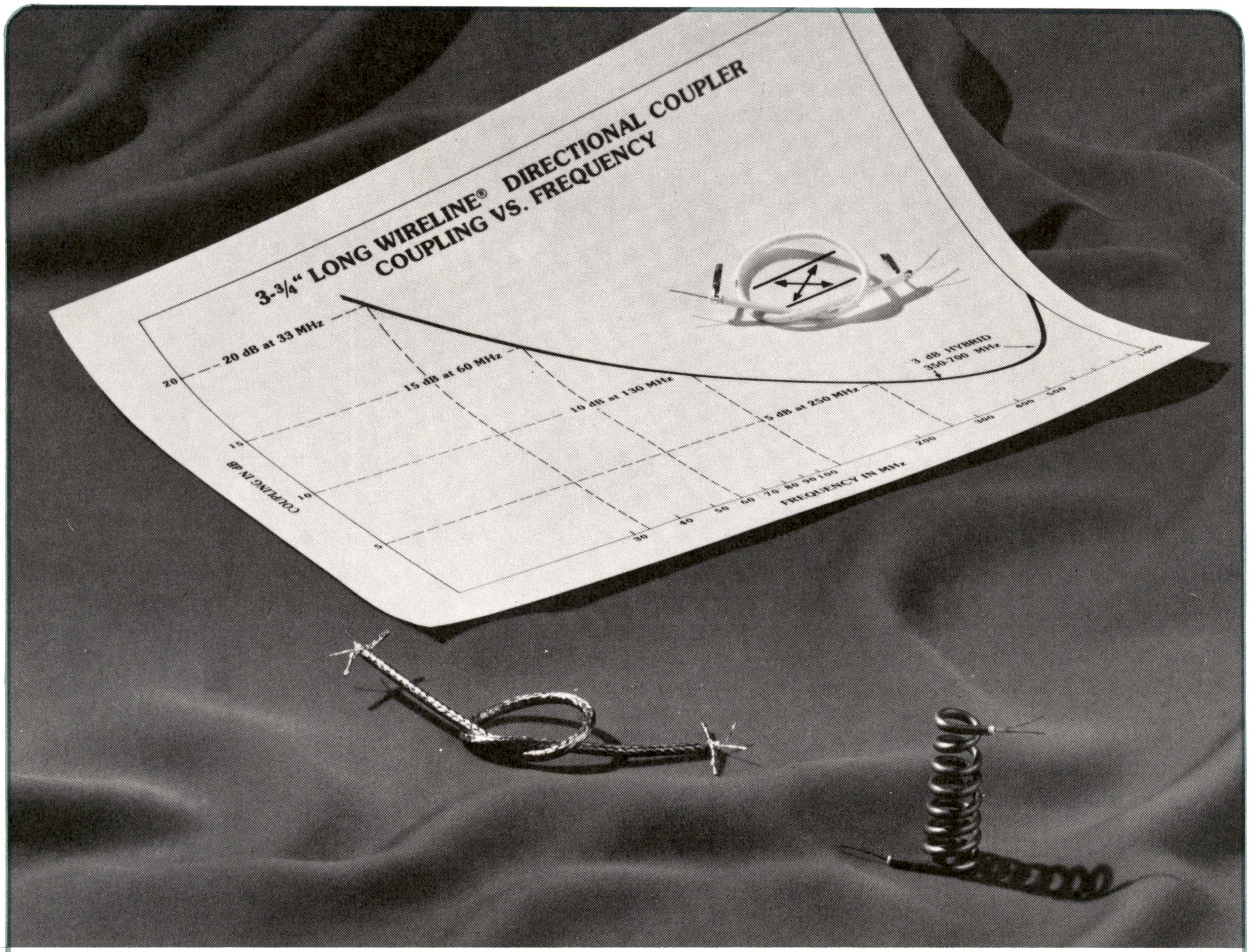
This early C-band bidirectional coupler was designed for the DYNASOAR program. Its most interesting feature is a pair of built-in sample-and-hold video detectors. The *hold* feature was added at the customer's request when it was realized that there was zero probability that the system's built-in test sampling period would coincide with the transmitted RF pulse period.

SHOWN APPROXIMATELY HALF-SIZE



sage
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (FLEXIBLE CABLE-LIKE CONSTRUCTIONS OF TEMLINE®)

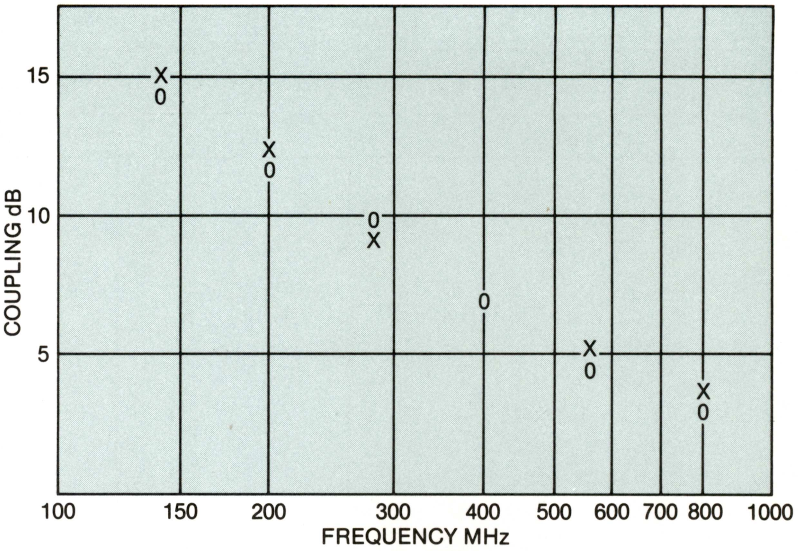

3-3/4" LONG WIRELINE® DIRECTIONAL COUPLER
COUPLING VS. FREQUENCY
20 dB at 33 MHz
15 dB at 60 MHz
10 dB at 130 MHz
5 dB at 250 MHz
3 dB HYBRID 350-700 MHz
COUPLING IN dB
20
15
10
5
FREQUENCY IN MHz
30
40
50
60
70
80
90
100
200
300
400
500
1000

WIRELINE® couplers handle like wire, yet perform like machined couplers. The original WIRELINE units introduced by Sage Laboratories in 1968 have shown themselves to be a boon to designers in terms of design flexibility and cost reduction. Now, we are pleased to offer two new additional WIRELINE styles, braided copper and seamless copper tube, which provide even better shielding and higher power capability than the original. Both new types also can be soldered into your system more easily, and the solid copper style holds whatever shape you may wish to form. For all three WIRELINE styles, the tightest nominal coupling is 3 dB (quadrature hybrid at midband), which is obtained with a length equal to a quarter-wavelength. Shorter lengths yield looser coupling.

WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)

FEATURES

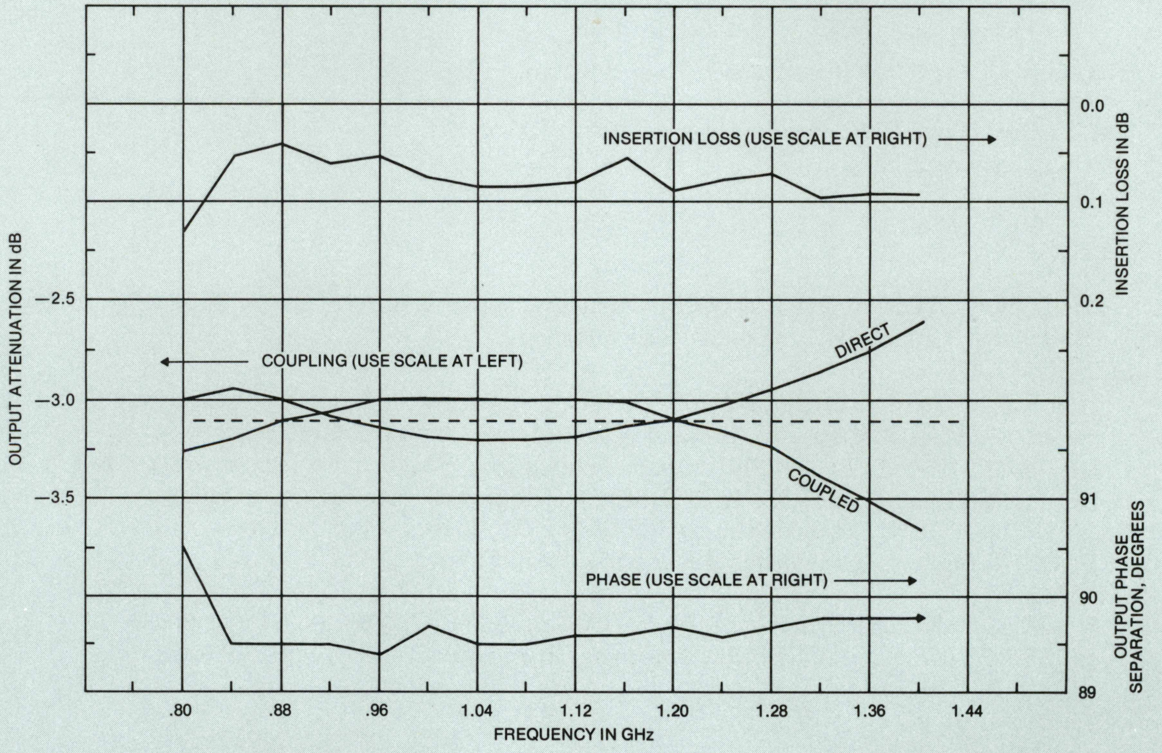
- low-loss low-cost
- low VSWR & high isolation
- 3 styles available (foil shield & braided copper styles can be tied in knots... seamless copper tube style holds whatever shape you wish to form)
- ±1° deviation from phase quadrature between coupled & main outputs
- octave band performance from 50MHz to 2400 MHz
- 50-ohm characteristic impedance standard ... others available
- 100 watts average power handling capability



Test data on a short segment of Wireline demonstrating the close agreement between theoretical and measured curves. 0 = Measured, X = Theoretical.

TYPICAL PERFORMANCE CURVES

(TRACED FROM POINT-TO-POINT PLOTS SUPPLIED BY CUSTOMERS AFTER EVALUATING AN H SERIES 3-dB WIRELINE HYBRID IN THEIR OWN TEST FIXTURE)



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SPECIFICATIONS

STANDARD TOLERANCES & RATINGS AT 300 MHz & 25°C IN SUITABLE TEST FIXTURE

PARAMETER	UNIT	MINIMUM	NOMINAL	MAXIMUM
Quarter-wave Coupling (excluding loss)	dB	2.4	2.9	3.3
Insertion Loss	dB		0.2	0.3
Isolation	dB	20	22	
VSWR (referenced to 50 ohms)			1.1	1.2
Power, Average	Watts			100*
Power, Peak	Watts			2000
Ambient Temperature				
H Series (foil shield)	°C			105**
HB Series (braided copper)	°C			150
HC Series (solid copper)	°C			150
60 Hz Dielectric Breakdown Voltage between coupled pair	V rms	500	2000	
Bend Radius (with no electrical degradation)				
H Series (foil shield)	Inches	0.30		
HB Series (braided copper)	Inches	0.25		
HC Series (solid copper)	Inches	0.20		
Weight … H Series	Grams/Inch		0.36	
HB Series	Grams/Inch		0.62	
HC Series	Grams/Inch		0.55	
Dimensions & Other Mechanical Details … See drawings				

* At ambients above 55°C, derate power to 50% at 105°C

** 85°C in hard vacuum

MATERIALS

CENTER CONDUCTORS: .0124 ±.0002 diameter copper wire per QQ-W-343, silver plated per QQ-S-365 Type III, Grade A, 40 micro-inch thick minimum

SHIELD CONDUCTOR

H SERIES (FOIL TYPE): per QQ-W-343, .003 ±.0005 inch thick by .075 ±.020 inch wide … silver plated per QQ-S-365, Type III, Grade A, 40 micro-inch thick minimum

HB SERIES (BRAIDED COPPER): double braided with .004 diameter copper wire per QQ-W-343

HC SERIES (SEAMLESS COPPER TUBE): .011 thick wall seamless copper tubing

PRIMARY INSULATION: Polyimide film per MIL-P-46112, .0016 ±.0002 inch thick

INNER JACKET: tape wrapped Polytetraflouroethylene (PTFE) per L-P-523

OUTER JACKET:

H SERIES (FOIL TYPE): laminated Mylar/PVC per L-P-377, .006 ±.001 inch thick

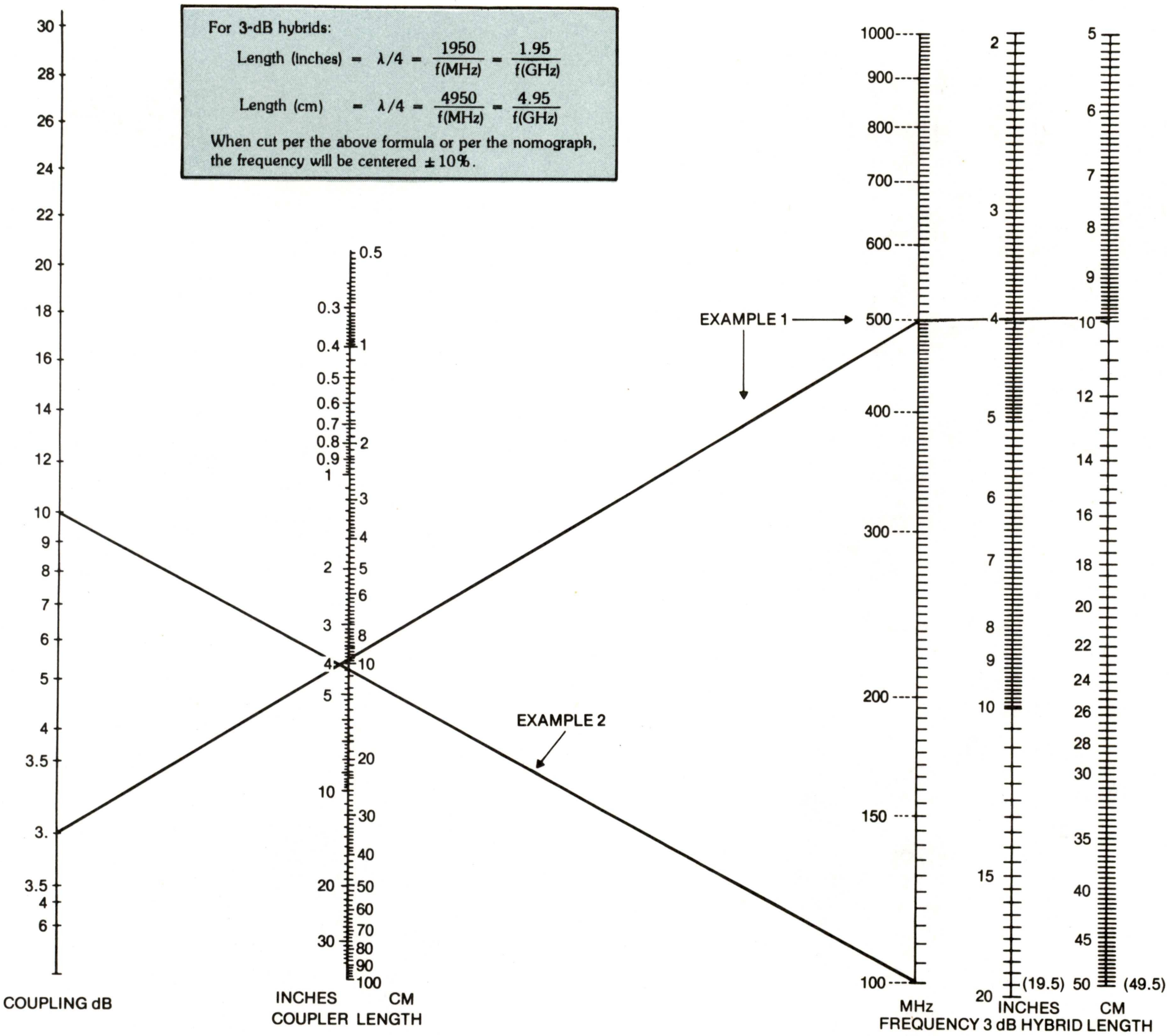
HB SERIES (BRAIDED COPPER): Polyimide film per MIL-P-46112 with FEP binder

For 3-dB hybrids:

$$\text{Length (inches)} = \lambda/4 = \frac{1950}{f(\text{MHz})} = \frac{1.95}{f(\text{GHz})}$$

$$\text{Length (cm)} = \lambda/4 = \frac{4950}{f(\text{MHz})} = \frac{4.95}{f(\text{GHz})}$$

When cut per the above formula or per the nomograph, the frequency will be centered ± 10%.

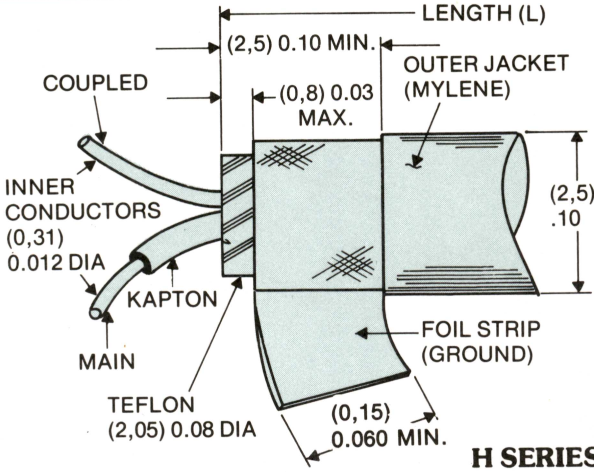


HOW TO DESIGN A 3-dB WIRELINE HYBRID. On the nomograph, Example 1 shows how to determine the length of a 3-dB hybrid for operation at a center frequency of 500 MHz. A horizontal line through 500 MHz intersects the 3-dB length scale at 3.9 inches (9,9 cm). This is the length, L, defined on the facing page (to the end of the Teflon dielectric). The left half of the nomograph can be used to determine coupling vs. frequency. As shown, at 500 MHz the nominal coupling is 3 dB. A straight edge passing through the 3.9 inch length and other frequencies would show that the coupling is flat within about 1 dB from 300-700 MHz with this length.

DIRECTIONAL COUPLERS. Lay a straight edge between desired coupling and center frequency. Example 2 shows that a 4.3-inch (10,9 cm) length is required for 10-dB coupling at 100 MHz.

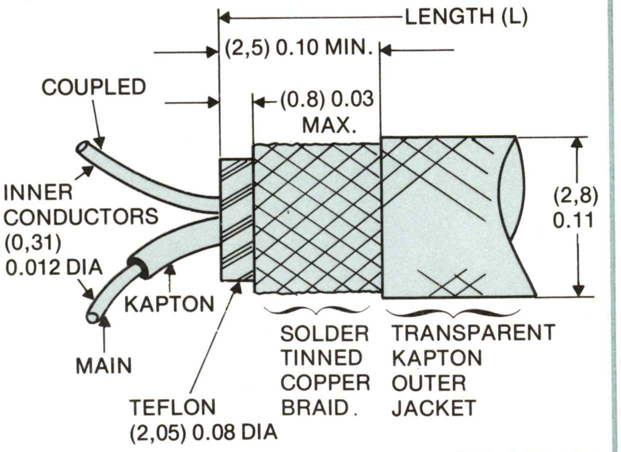
EXTENDING THE NOMOGRAPH SCALE. Multiply the frequency scale by any convenient constant and divide the length scales by the same constant. EXAMPLE: a 3-dB coupler at 1000 MHz (twice the center frequency of Example 1) would be 1.95 inches (4,95 cm) long (half the length of Example 1).

WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)
MECHANICAL DATA
(FACTORY-TRIMMED UNITS)



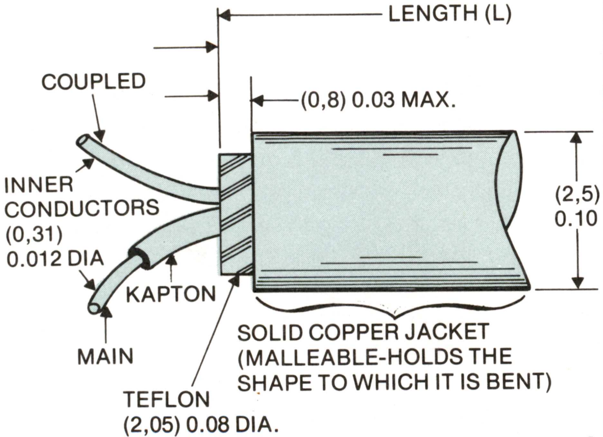
LENGTH (L)
(2,5) 0.10 MIN.
OUTER JACKET (MYLENE)
COUPLED
(0,8) 0.03 MAX.
INNER CONDUCTORS (0,31) 0.012 DIA
(2,5) .10
KAPTON
FOIL STRIP (GROUND)
MAIN
TEFLON (2,05) 0.08 DIA
(0,15) 0.060 MIN.

H SERIES



LENGTH (L)
(2,5) 0.10 MIN.
COUPLED
(0.8) 0.03 MAX.
INNER CONDUCTORS (0,31) 0.012 DIA
(2,8) 0.11
KAPTON
MAIN
SOLDER TINNED COPPER BRAID.
TRANSPARENT KAPTON OUTER JACKET
TEFLON (2,05) 0.08 DIA

HB SERIES



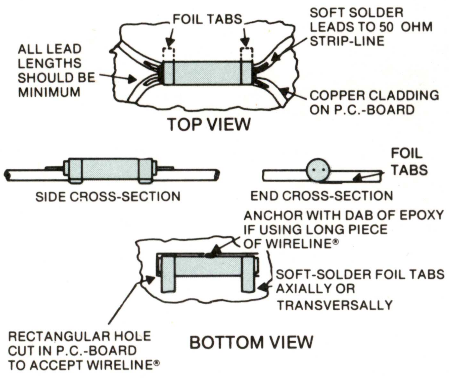
LENGTH (L)
COUPLED
(0,8) 0.03 MAX.
INNER CONDUCTORS (0,31) 0.012 DIA
(2,5) 0.10
KAPTON
MAIN
SOLID COPPER JACKET (MALLEABLE-HOLDS THE SHAPE TO WHICH IT IS BENT)
TEFLON (2,05) 0.08 DIA.

HC SERIES

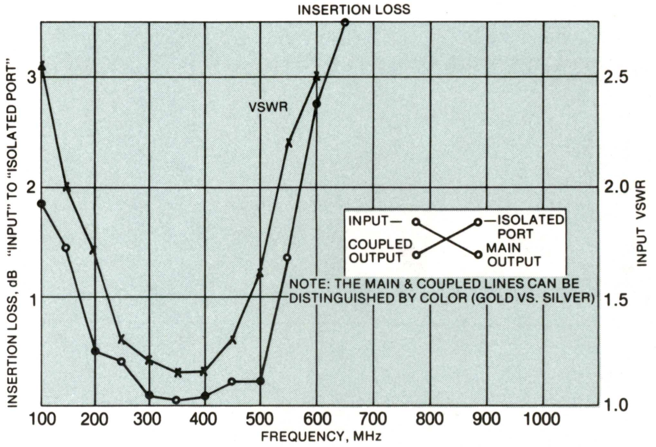
WIRELINE OCTAVE-BAND 3dB HYBRIDS			LENGTH, (L) ±1%	
MODEL NUMBER (Prefix H, HB, or HC)	FREQUENCY RANGE (MHz)	CENTER FREQUENCY (MHz)	(INCHES)	(MM)
50-100	50-100	75	26.00	660,4
60-120	60-120	90	21.66	550,3
70-140	70-140	105	18.57	471,7
80-160	80-160	120	16.25	412,7
90-180	90-180	135	14.44	366,8
100-200	100-200	150	13.00	330,2
110-220	110-220	165	11.81	300,1
120-240	120-240	180	10.83	275,1
130-260	130-260	195	10.00	254,0
140-280	140-280	210	9.28	235,8
150-300	150-300	225	8.66	220,1
160-320	160-320	240	8.12	206,3
170-340	170-340	255	7.64	194,2
180-360	180-360	270	7.22	183,4
190-380	190-380	285	6.84	173,7
200-400	200-400	300	6.50	165,1
210-420	210-420	315	6.19	157,2
220-440	220-440	330	5.90	150,0
230-460	230-460	345	5.65	143,5
240-480	240-480	360	5.41	137,5
250-500	250-500	375	5.20	132,0
260-520	260-520	390	5.00	127,0
270-540	270-540	405	4.81	122,2
280-560	280-560	420	4.64	117,9
290-580	290-580	435	4.48	113,8
300-600	300-600	450	4.33	110,0
310-620	310-620	465	4.19	106,5
320-640	320-640	480	4.06	103,1
330-660	330-660	495	3.98	100,0
340-680	340-680	510	3.82	97,1
350-700	350-700	525	3.71	94,3
360-720	360-720	540	3.61	91,7
370-740	370-740	555	3.51	89,2
380-760	380-760	570	3.42	86,8
390-780	390-780	585	3.33	84,6
400-800	400-800	600	3.25	82,5
410-820	410-820	615	3.17	80,5
420-840	420-840	630	3.09	78,6
430-860	430-860	645	3.02	76,7
440-880	440-880	660	2.95	75,0
450-900	450-900	675	2.88	73,3
460-920	460-920	690	2.82	71,7
470-940	470-940	705	2.76	70,2
480-960	480-960	720	2.70	68,7
490-980	490-980	735	2.65	67,3
500-1000	500-1000	750	2.60	66,0
510-1020	510-1020	765	2.54	64,7
520-1040	520-1040	780	2.50	63,5
530-1060	530-1060	795	2.45	62,3
540-1080	540-1080	810	2.40	61,1
550-1100	550-1100	825	2.36	60,0
560-1120	560-1120	840	2.32	58,9
570-1140	570-1140	855	2.28	57,9
580-1160	580-1160	870	2.24	56,9
590-1180	590-1180	885	2.20	55,9
600-1200	600-1200	900	2.16	55,0
700-1400	700-1400	1050	1.85	47,1
800-1600	800-1600	1200	1.62	41,2
900-1800	900-1800	1350	1.44	36,6
1000-2000	1000-2000	1500	1.30	33,0
1100-2200	1100-2200	1650	1.18	30,0
1200-2400	1200-2400	1800	1.08	27,5

TO ORDER SPECIAL LENGTHS NOT SHOWN IN TABLE: Simply prefix desired length (in inches) with the desired series code. EXAMPLE: HB-3.5

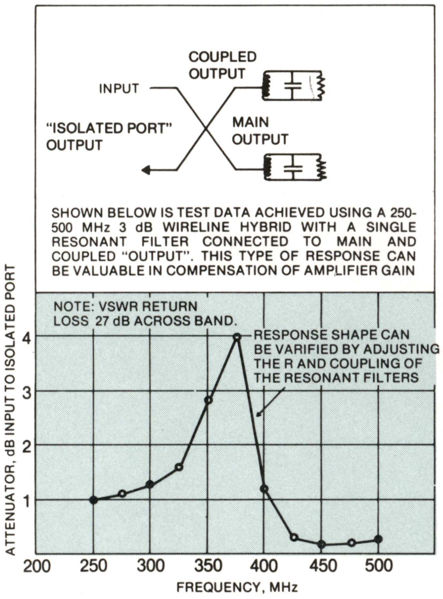
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)
APPLICATION NOTES


FOIL TABS
SOFT SOLDER LEADS TO 50 OHM STRIP-LINE
ALL LEAD LENGTHS SHOULD BE MINIMUM
COPPER CLADDING ON P.C.-BOARD
TOP VIEW
FOIL TABS
SIDE CROSS-SECTION
END CROSS-SECTION
ANCHOR WITH DAB OF EPOXY IF USING LONG PIECE OF WIRELINE®
SOFT-SOLDER FOIL TABS AXIALLY OR TRANSVERSALLY
RECTANGULAR HOLE CUT IN P.C.-BOARD TO ACCEPT WIRELINE®
BOTTOM VIEW

SUGGESTED METHOD FOR MOUNTING WIRELINE® IN TEFLON-FIBERGLASS MICROSTRIP CIRCUITS (.031/.062 THICK), WHERE OPTIMUM HIGH FREQUENCY PERFORMANCE IS IMPORTANT.

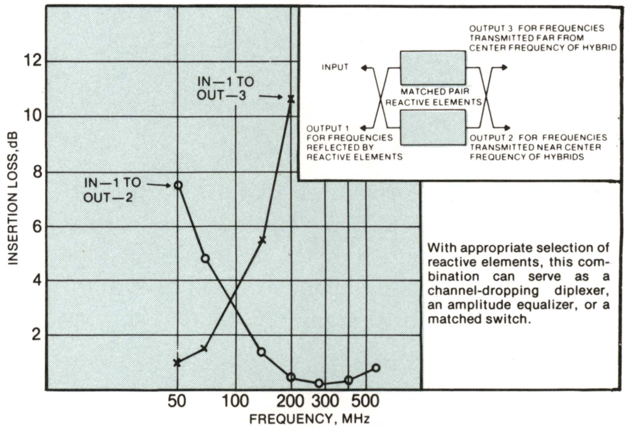


Test data on a 3-dB WIRELINE coupler used as a DC block (open circuit "outputs"—no DC path—all energy reflected out isolated port). Note that the coupler must be 3 dB for a given center frequency in this application, because as the coupling departs from 3 dB, the insertion loss and VSWR increase as shown by the curves. Note that the "coupled" and "main" output leads (see diagram in box) must be the same length to their open circuits. By short-circuiting the outputs, the same performance can be achieved, with the benefit of a DC return.



SHOWN BELOW IS TEST DATA ACHIEVED USING A 250-500 MHz 3 dB WIRELINE HYBRID WITH A SINGLE RESONANT FILTER CONNECTED TO MAIN AND COUPLED "OUTPUT". THIS TYPE OF RESPONSE CAN BE VALUABLE IN COMPENSATION OF AMPLIFIER GAIN

Use and performance of WIRELINE as a shaped attenuator. A 3-dB unit is necessary. Without the resistors in the filter circuits, this unit can function as a low loss group-delay compensating network for a bandpass filter.

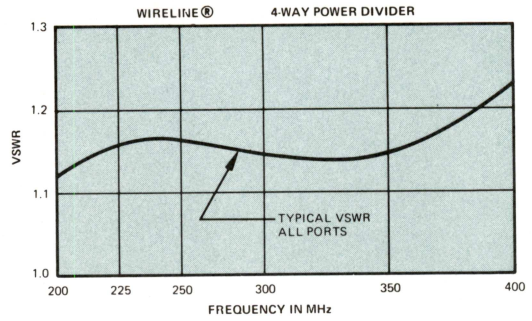


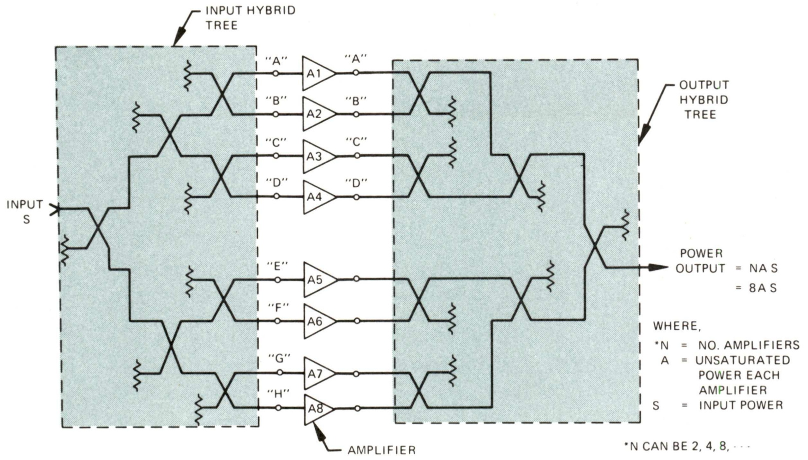
With appropriate selection of reactive elements, this combination can serve as a channel-dropping diplexer, an amplitude equalizer, or a matched switch.

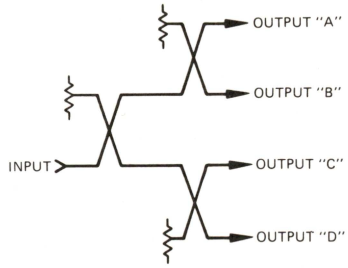
USE OF WIRELINE AS A DIPLEXER-DUPLEXER BUILDING BLOCK

With matched transmission lines in place of the reactive elements, the above combination can serve as a simple diplexer to separate a lower frequency signal from a higher frequency signal. In this case, the hybrids would be centered at the high frequency, and the low frequency signal would be transmitted to Output 3.

WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS APPLICATION NOTES (cont.)




INPUT HYBRID TREE
"A"
"B"
"C"
"D"
"E"
"F"
"G"
"H"
A1
A2
A3
A4
A5
A6
A7
A8
INPUT
S
OUTPUT HYBRID TREE
POWER OUTPUT = NA S
= 8A S
WHERE,
*N = NO. AMPLIFIERS
A = UNSATURATED POWER EACH AMPLIFIER
S = INPUT POWER
AMPLIFIER
*N CAN BE 2, 4, 8, . . .


INPUT
OUTPUT "A"
OUTPUT "B"
OUTPUT "C"
OUTPUT "D"

ELECTRICAL SCHEMATIC

4 WAY POWER DIVIDER

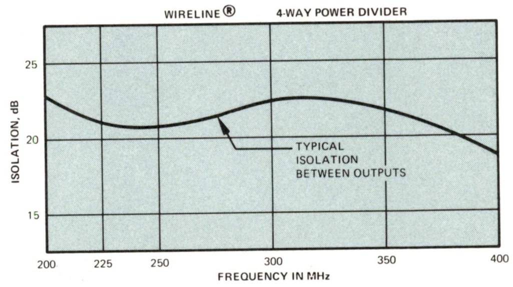
One typical application where the WIRELINE hybrids are ideal is for hybrid trees in solid state amplifiers, where the outputs of parallel amplifiers are combined to yield the arithmetic sum of their output powers.

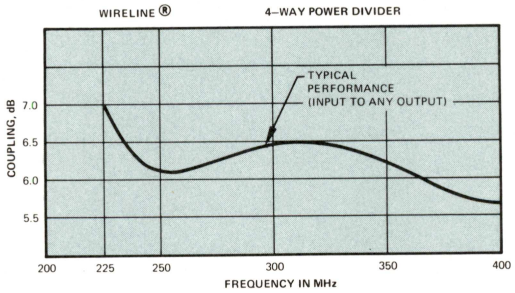
$$P_{OUT} = N \bullet P_{SAT}$$

where N is the number of amplifiers in the circuit, and P_{SAT} is the saturated power of each amplifier.

WIRELINE hybrid trees can be supplied as a package, complete with hook-up instructions for use in this type of application.

Shown on this page are diagrams and performance curves for a 4-way power divider employing three WIRELINE hybrids, covering 225-400 MHz.





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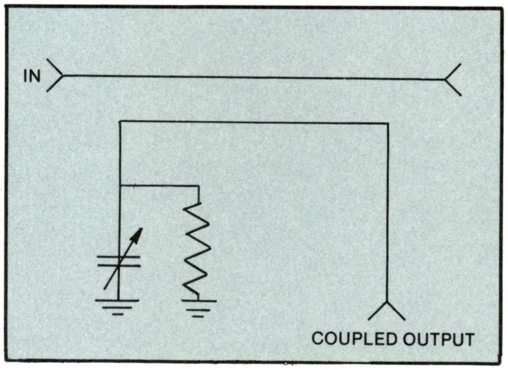
LABORATORIES · INC

WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS APPLICATION NOTES (conclusion)

VARIABLE COUPLER

A variable coupler can be constructed by terminating the normal coupler output port in a variable capacitor, in parallel with an RF termination.



POWER MONITORS

20 dB and weaker couplers designed per the nomograph have a coupling slope of 6 dB per octave. This can be compensated for by shunting the power monitor video detector with a capacitor. The value of capacitance is dependent on the video load impedance and operating frequency.

HOW TO ORDER WIRELINE®

BULK ORDERS: If you wish to order a given length of WIRELINE so that you can make your own units, simply place a B prefix before the WIRELINE style series you prefer, and specify the length in feet. (Minimum order is 10 feet.) If you order more than 50 feet, please note that we cut the WIRELINE into approximately 50-foot lengths for quality control tests prior to shipment. (5-foot lengths for BHC)

EXAMPLES:
BH-20 = 20 feet of H series (foil shield) WIRELINE
BHB-60 = 60 feet of HB series (braided copper) WIRELINE
BHC-90 = 90 feet of HC series (solid copper) WIRELINE

Prices are listed on the enclosed sheet. For orders above 100 feet, please contact the factory sales office. Complete trimming instructions will be shipped with your WIRELINE.

FINISHED UNITS: To order units that will be cut and trimmed by Sage, please use the model numbers shown in the table on the Mechanical Data page. Simply select the series you prefer, select your center frequency, and add the series prefix to the model number.

EXAMPLES:
H350-700 = an H series unit centered at 525 MHz
HB100-200 = an HB series unit centered at 150 MHz
HC800-1600 = an HC series unit centered at 1200 MHz

Prices are listed on the attached sheet. Please specify quantity. For prices on more than 50 units, please contact the factory sales office.

TO ORDER SPECIAL LENGTHS NOT SHOWN IN TABLE: Simply prefix your desired length (in inches)
EXAMPLE: HB-3.5

OTHER IMPEDANCE VALUES: 75-ohm WIRELINE with a braided (0.19 inch dia.) outer shield is stocked in limited quantity. Contact factory for availability.

SPECIAL REQUIREMENTS

Contact Sage Laboratories if you have special requirements such as higher power capability, impedances other than 50 ohms, etc. The following minimum information should be furnished for quotation.

Characteristic Impedance:
Quarter-wavelength coupling value:
Peak power value:
Average power value:
Operating Frequency:
Operating Temperature:
Style (foil, braid, or tube):
Quantity required:
Cut lengths (if to be cut & stripped):

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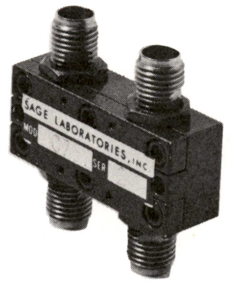
MINIATURE OCTAVE-BAND 3-dB QUADRATURE HYBRIDS
DC751 SERIES

FEATURES

- −54°C to +125°C operational temperature range
- guaranteed to meet MIL-E-5400 Class 3
- milled & sealed aluminum housings ensure RFI & environmental shielding
- passivated stainless steel SMA connectors with interface per MIL-C-39012
- models from 0.5-18 GHz
- flexible design permits easy modification to meet special requirments



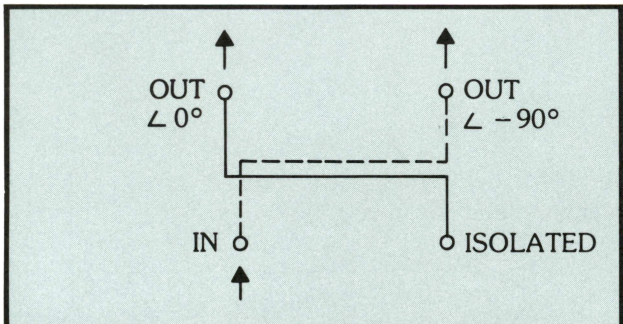
ACTUAL SIZE

CONSTRUCTION

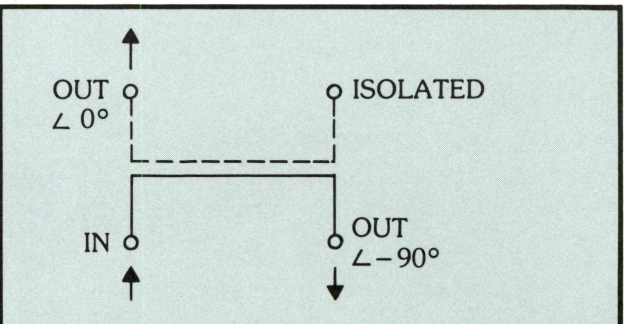
Sage miniature octave-band 3-dB quadrature hybrids use solid stripline circuit techniques. Milled aluminum housings ensure complete environmental and RFI shielding, and epoxy sealing makes the units impervious to humidity and salt spray. These extremely rugged assemblies are unaffected by mechanical shock, vibration, and temperature extremes to the full extent of MIL-E-5400, Class 3.

Units are available in both crossover and non-crossover configurations in all frequency bands. Special frequency bands can often be accommodated with minimum need for special tooling. Your inquiries are cordially invited.

SMA female connectors are standard. SMA male can be installed on request.



CROSSOVER COUPLER CONFIGURATION



NON-CROSSOVER COUPLER CONFIGURATION

NOTE: The DC model numbers signify crossover hybrids. The D model numbers signify non-crossover hybrids. Example: Model DC751 is crossover type - Model D751 is non-crossover type.

MINIATURE OCTAVE-BAND 3-dB QUADRATURE HYBRIDS
ELECTRICAL SPECIFICATIONS

NOTE: "DC" model numbers signify crossover hybrids - "D" signifies non-crossover

MODEL NUMBER	FREQUENCY (GHz)	COUPLING (dB)	MAX. LOSS (dB)	FLATNESS (dB)	MAX. VSWR	MIN. ISOLATION (dB)	TYPICAL DEVIATION FROM PHASE QUADRATURE*	POWER HANDLING CAPABILITY**	
								AVERAGE (WATTS)	PEAK (KW)
DC 751	.5-1	3	.15	± .5	1.10	25	± 1.5°	100	3
D 751	.5-1	3	.15	± .5	1.10	25	± 1.5°	100	3
DC 752	1-2	3	.2	± .5	1.10	25	± 1.5°	100	3
D 752	1-2	3	.2	± .5	1.10	25	± 1.5°	100	3
DC 752E	1.3-2.6	3	.2	± .5	1.15	25	± 1.5°	100	3
D 752E	1.3-2.6	3	.2	± .5	1.15	25	± 1.5°	100	3
DC 753	2-4	3	.25	± .5	1.15	25	± 2°	100	3
D 753	2-4	3	.25	± .5	1.15	25	± 2°	100	3
DC 753E	2.6-5.2	3	.25	± .5	1.20	22	± 2°	100	3
D 753E	2.6-5.2	3	.25	± .5	1.20	22	± 2°	100	3
DC754	4-8	3	.3	± .5	1.25	20	± 2°	100	3
D 754	4-8	3	.3	± .5	1.25	20	± 2°	100	3
DC 754E	4.8-9.6	3	.35	± .5	1.25	17	± 2°	100	3
D 754E	4.8-9.6	3	.35	± .5	1.25	17	± 2°	100	3
DC 755	7-12.4	3	.5	± .5	1.35	15	± 4°	50	1.5
D 755	7-12.4	3	.5	± .5	1.35	15	± 4°	50	1.5
DC 756	12-18	3	.7	± .5	1.35	17	± 4°	50	1.5
D 756	12-18	3	.7	± .5	1.35	17	± 4°	50	1.5
DC 756E	6.5-18	3	.8	± .5	1.35	16	± 4°	50	1.5
D 756E	6.5-18	3	.8	± .5	1.35	16	± 4°	50	1.5

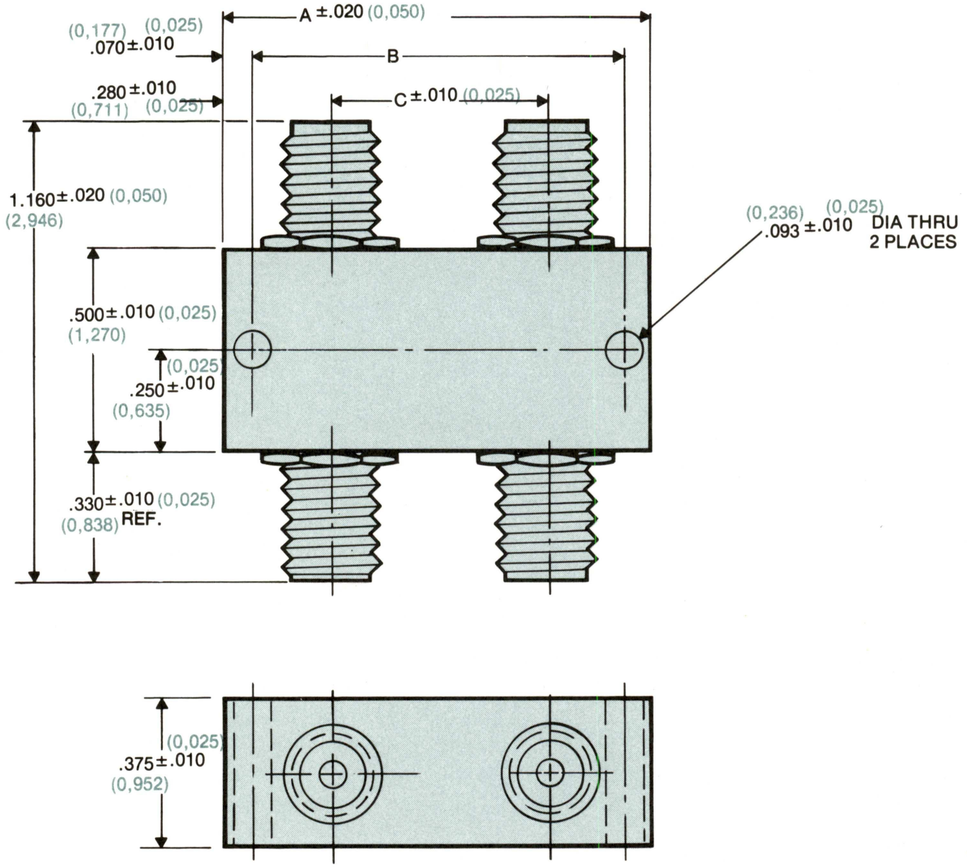
*For a nominal additional testing charge, Sage Laboratories will guarantee meeting the typical phase characteristics indicated above.
**See derating curves.

DEFINITION OF TERMS

Flatness is measured as the maximum deviation of the coupled and straight-through output ports from the mean coupling at each frequency.

The specified *loss* is the actual dissipative and reflective loss due to VSWR. It does *not* include coupling loss.

MINIATURE OCTAVE-BAND 3-dB QUADRATURE HYBRIDS
MECHANICAL DATA


A ±.020 (0,050)
(0,177) (0,025)
.070±.010
B
.280±.010
(0,711) (0,025)
C ±.010 (0,025)
1.160±.020 (0,050)
(2,946)
(0,236) (0,025)
.093 ±.010 DIA THRU
2 PLACES
.500±.010 (0,025)
(1,270)
(0,025)
.250±.010
(0,635)
.330±.010 (0,025)
(0,838) REF.
(0,025)
.375±.010
(0,952)

MATERIALS & FINISHES

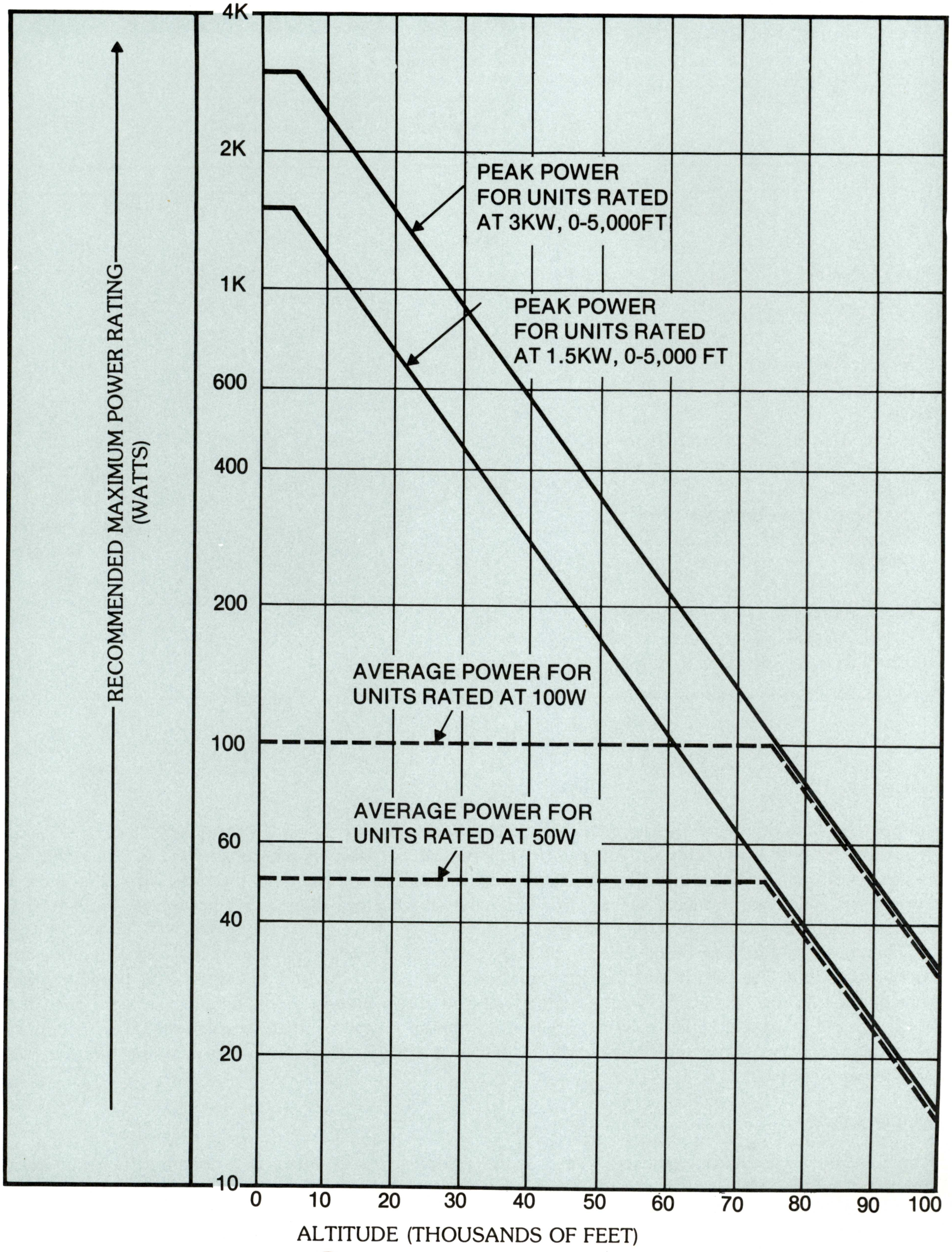
Housings: machined aluminum
Sealing: epoxy
Finish: Sage Hammertone green paint

Connectors: SMA female (standard), passivated stainless steel shells, interfaces per MIL-C-39012

Alternative connectors, materials & finishes on special order

MODEL NUMBERS	CASE STYLE	FRE-QUENCY (GHz)	DIMENSIONS (SEE DRAWING)						WEIGHTS	
			A"	A (cm)	B"	B (cm)	C"	C (cm)	Ounces	Grams
DC751, D751	A	.5-1	3.270	(8,305)	3.130	(7,950)	2.710	(6,883)	1.4	40
DC752, D752	B	1-2	1.841	(4,676)	1.701	(4,320)	1.281	(3,253)	1.0	28
DC752E, D752E	C	1.3-2.6	1.500	(3,810)	1.360	(3,454)	.940	(2,387)	1.2	34
DC753, D753	D	2-4	1.195	(3,035)	1.055	(2,679)	.635	(1,612)	.5	14
DC753E, D753E	E	2.6-5.2	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.5	14
DC754, D754	E	4-8	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.5	14
DC754E, D754E	D	4.8-9.6	1.195	(3,035)	1.055	(2,679)	.635	(1,612)	.5	14
DC755, D755	E	7-12.4	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.5	14
DC756, D756	E	12.4-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.5	14
DC756E, D756E	E	6.5-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.5	14

MINIATURE 3-dB OCTAVE-BAND & BROADBAND QUADRATURE HYBRIDS PEAK & AVERAGE POWER DERATING CURVES (vs ALTITUDE)



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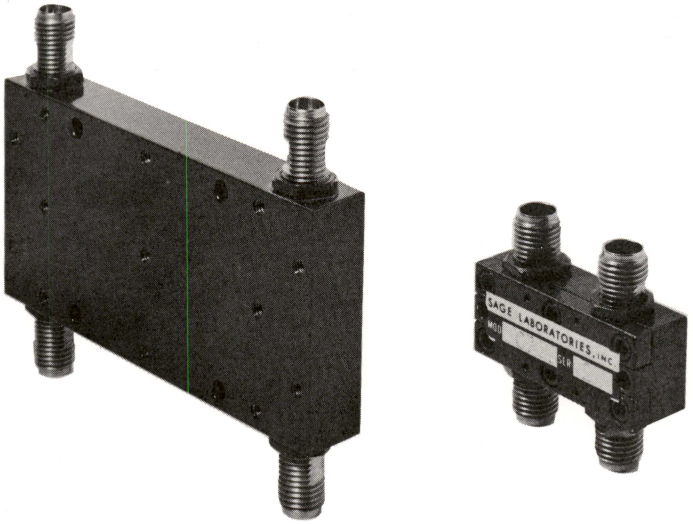
MINIATURE MULTI-OCTAVE-BAND 3-dB QUADRATURE HYBRIDS
2375 SERIES

FEATURES

- up to 18:1 bandwidths
- −54°C to +100°C operational temperature range
- guaranteed to meet MIL-E-5400 Class 2
- milled & sealed aluminum housings ensure RFI & environmental shielding
- passivated stainless steel SMA connectors with interface per MIL-C-39012
- models from 0.5-18 GHz
- small, rugged stripline construction
- flexible design permits easy modification to meet special requirements



CONSTRUCTION

The Sage 2375 series of multi-octave-band 3-dB quadrature hybrids offers 15 computer-aided designs for broadband applications ranging as high as 18:1 in bandwidths. All units are constructed in machined aluminum housings, and feature passivated stainless steel connectors. The assemblies are sealed to provide effective RFI and environmental sealing. Solid stripline construction eliminates voids which could lead to component vibration or moisture accumulation.

Hybrids of double-octave bandwidth or less consist of 3-section symmetrical couplers designed to provide maximum bandwidth and flatness, consistent with small size and low cost. The broader bandwidth designs consist of two 8.34-dB couplers within a single package, connected in tandem such that the net coupling is 3 dB. Each 8.34-dB coupler comprises a tapered multisection symmetrical coupled-line structure. This design approach results in excellent VSWR, directivity, and coupling flatness over multi-octave bandwidths.

APPLICATIONS

Hybrids in the Sage 2375 seris can be used as component parts of quadrature antenna feed networks, broadband mixers, diplexers, matched PIN diode switches and attenuators, and a variety of other networks used in radar, ECM, communications, and test systems.

MINIATURE MULTI-OCTAVE-BAND 3-dB QUADRATURE HYBRIDS ELECTRICAL SPECIFICATIONS

MODEL NUMBER (CONSTRUCTION)	FRE-QUENCY (GHz)	COU-PLING (dB)	MAX. LOSS (dB)	FLAT-NESS (dB)	MAX. VSWR	MIN. ISOLA-TION (dB)	TYPICAL DEVIATION FROM PHASE QUADRA-TURE (1)	POWER HANDLING CAPABILITY (2)	
								AVERAGE (WATTS)	PEAK (KW)
2375-1 (crossover) 2376-1 (non-crossover)	.5-2.0	3	.40	±0.5	1.15:1	24	± 2°	50	1.5
2375-2 (crossover) 2376-2 (non-crossover)	1.0-4.0	3	.40	±0.5	1.25:1	22	± 3°	50	1.5
2375-3 (crossover) 2376-3 (non-crossover)	2.0-8.0	3	.40	±0.5	1.30:1	20	± 5°	50	1.5
2375-4 (crossover) 2376-4 (non-crossover)	4.0-12.4	3	.40	±0.5	1.35:1	18	± 5°	50	1.5
2375-5 (crossover) 2376-5 (non-crossover)	6.5-18	3	.60	±0.5	1.35:1	16	± 4°	50	1.5
2375-6 (crossover)	1.0-12.4	3	.70	±0.6	1.35:1	18	± 5°	50	1.5
2375-7 (crossover)	1.0-18.0	3	.80(6)	±1.0	1.50:1	15	± 10°	50	1.5
2375-8 (crossover)	2.0-12.4	3	.50(5)	±0.5	1.35:1	18	± 6°	50	1.5
2375-9 (crossover)	2.0-18.0	3	.60(3)	±1.0	1.45:1	20(4)	± 8°	50	1.5
2375-10 (crossover)	2.0-18.0	3	.80(3)	±0.6	1.45:1	20(4)	±8°	50	1.5

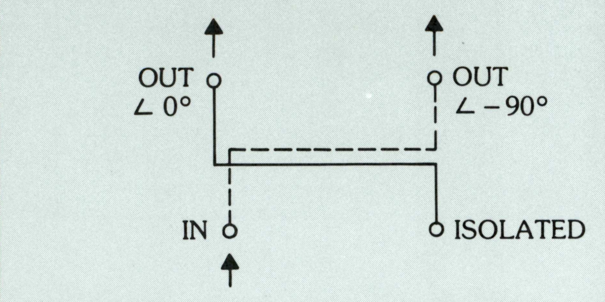
NOTES: (1) For a nominal additional testing charge, Sage will quarantee meeting the typical phase characteristics indicated above.

(2) 0-5000 feet: See derating curves preceding this section
(3) 1 dB loss 6-12.4 GHz ... 1.25 dB loss 12.4-18 GHz
(4) 16 dB minimum from 12.4-18 GHz
(5) 0.7 dB maximum from 8-12.4 GHz
(6) 1.2 dB 6-12 GHz ... 1.6 dB 12-18 GHz
(7) 1.0 dB maximum from 6-12.4 GHz

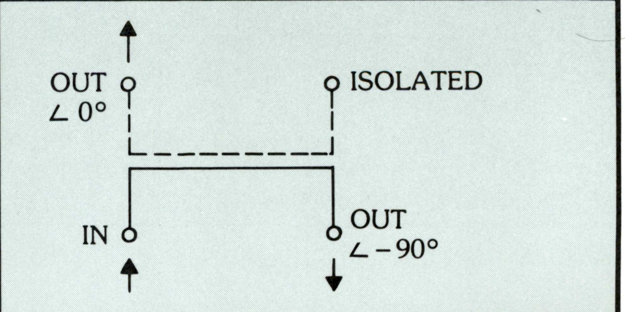
DEFINITION OF TERMS

Flatness is measured as the maximum deviation of the coupled and straight-through output ports from the mean coupling at each frequency.

The specified *loss* is the actual dissipative and reflective loss due to VSWR. It does *not* include coupling loss.



CROSSOVER COUPLER CONFIGURATION



NON-CROSSOVER COUPLER CONFIGURATION

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MINIATURE MULTI-OCTAVE-BAND 3-dB QUADRATURE HYBRIDS
MECHANICAL DATA

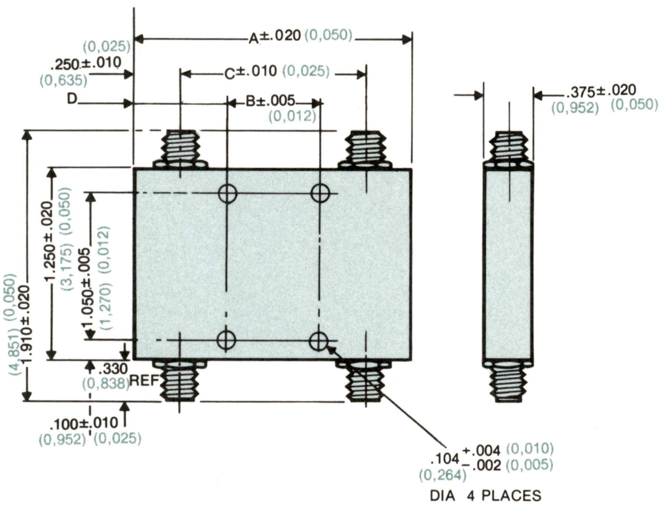
A±.020 (0,050)
(0,025)
.250±.010
(0,635)
C±.010 (0,025)
D
B±.005
(0,012)
.375±.020
(0,952) (0,050)
1.250±.020 (3,175) (0,050)
1.050±.005 (1,270) (0,012)
(4,851) (0,050)
1.910±.020
.330
(0,838) REF
.100±.010
(0,952) (0,025)
.104 +.004 (0,010) −.002 (0,005)
(0,264)
DIA 4 PLACES

FIGURE 1

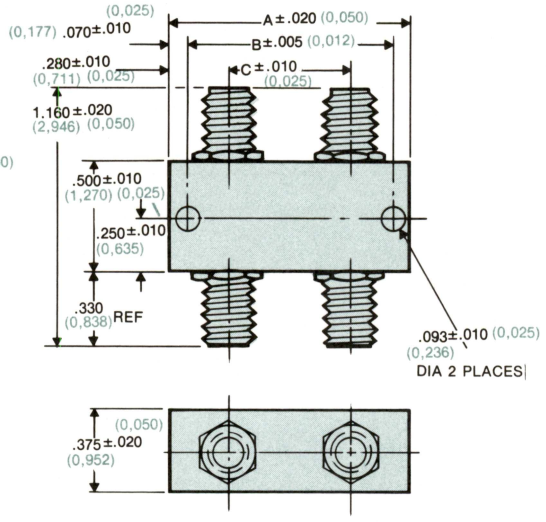
(0,025)
(0,177) .070±.010
A±.020 (0,050)
B±.005 (0,012)
.280±.010
(0,711) (0,025)
C±.010
(0,025)
1.160±.020
(2,946) (0,050)
.500±.010
(1,270) (0,025)
.250±.010
(0,635)
.330
(0,838) REF
.093±.010 (0,025)
(0,236)
DIA 2 PLACES
(0,050)
.375±.020
(0,952)

FIGURE 2

MATERIALS & FINISHES

Housings: machined aluminum
Sealing: epoxy
Finish: green epoxy paint with primer

Connectors: SMA female (standard), passivated stainless steel shells, interfaces per MIL-C-39012

Alternative connectors, materials & finishes on special order

MODEL NUMBERS	SEE FIGURE	FRE-QUENCY (GHz)	DIMENSIONS (SEE DRAWINGS)								WEIGHT	
			A"	A (cm)	B"	B (cm)	C"	C (cm)	D"	D (cm)	OUNCES	GRAMS
2375-1, 2376-1	2	5-2	5.360	(13,614)	5.220	(13,258)	4.800	(12,192)			2.1	60
2375-2, 2376-2	2	1-4	2.972	(7,548)	2.832	(7,193)	2.412	(6,126)			1.4	40
2375-3, 2376-3	2	2-8	1.779	(4,518)	1.639	(4,163)	1.219	(3,096)			1.2	34
2375-4, 2376-4	2	4-12.4	1.313	(3,335)	1.173	(2,979)	.753	(1,912)			0.7	20
2375-5, 2376-5	2	6.5-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)			0.5	14
2375-6	1	1-12.4	3.405	(8,647)	2.000	(5,079)	2.902	(7,370)	.701	(1,781)	3.4	97
2375-7	1	1-18	2.535	(6,438)	1.131	(2,872)	2.031	(5,158)	.700	(1,778)	2.3	65
2375-8	1	2-12.4	2.645	(6,717)	1.243	(3.157)	2.143	(5,442)	.700	(1,778)	2.6	74
2375-9	1	2-18	2.030	(5,155)	.627	(1,592)	1.527	(3,878)	.700	(1,778)	2.0	57
2375-10	1	2-18	2.430	(6,171)	1.027	(2,608)	1.927	(4,894)	.700	(1,778)	2.2	62

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COBRID® HIGH POWER 3-dB QUADRATURE HYBRIDS (BRANCH LINE)

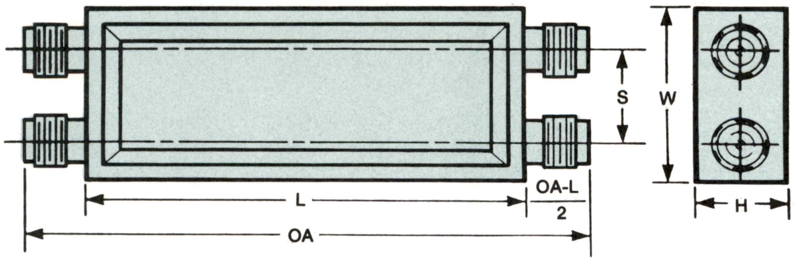
FEATURES

- rugged air-filled construction handles full coaxial line power with adjacent coupled arms
- 7 models cover 0.96-12 GHz
- 90° phase differential between output ports

ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FREQUENCY RANGE	NOMINAL VSWR	COUPLING	MINIMUM ISOLATION
706	960- 1200 MHz	1.30	3 dB ± 0.2 dB	16 dB
705	1100- 1600 MHz	1.30	3 dB ± 1.0 dB	15 dB
702	2600- 3200 MHz	1.30	3 dB ± 0.2 dB	20 dB
711	3500- 4600 MHz	1.30	3 dB ± 0.2 dB	19 dB
701	5000- 6000 MHz	1.30	3 dB ± 0.2 dB	20 dB
710	7500-10,000 MHz	1.40	3 dB ± 1.0 dB	20 dB
704	8000-12,000 MHz	1.40	3 dB ± 1.3 dB	17 dB

MECHANICAL DATA



MATERIALS & FINISHES

All models fabricated in aluminum
Coax contacts (beryllium copper) silver-plated & rhodium-flashed
Connectors irridited

Other body surfaces painted SAGE Hammertone Green
All SAGELINE materials & finishes to Govt. specs.
Alternative materials & finishes available on special order

MODEL NUMBER	CONNECTORS FEMALE	OA" (cm)	L" (cm)	W" (cm)	H" (cm)	S" (cm)	WEIGHT	
							POUNDS, OUNCES	GRAMS
706	Type N	19.750 (50,165)	18.750 (47,625)	9.375 (23,812)	4.000 (10,160)	5.281 (13,414)	22 lb.	10,000
705	Type N	16.500 (41,910)	15.500 (39,370)	7.750 (19,685)	3.500 (8,890)	4.250 (10,795)	16 lb.	7,257
702	Type N	8.000 (20,320)	7.000 (17,780)	3.750 (9,525)	1.500 (3,810)	2.000 (5,080)	2 lb. 7 oz.	1,106
711	Type N	6.500 (16,510)	5.500 (13,970)	2.875 (7,302)	1.437 (3,651)	1.500 (3,810)	1 lb. 10 oz.	737
701	Type N	4.875 (12,382)	3.875 (9,842)	2.000 (5,080)	1.000 (2,540)	1.062 (2,698)	8.5 oz.	240
710	TNC	3.000 (7,620)	2.062 (5,237)	1.531 (3,888)	.750 (1,905)	.656 (1,666)	4.0 oz.	113
704	TNC	3.000 (7,620)	2.062 (5,237)	1.531 (3,888)	.750 (1,905)	.656 (1,666)	4.0 oz.	113

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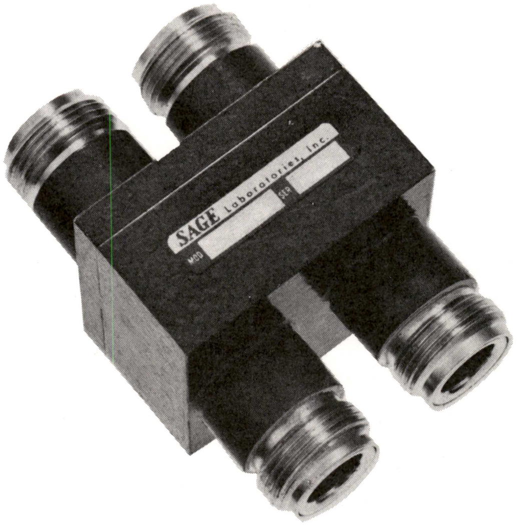
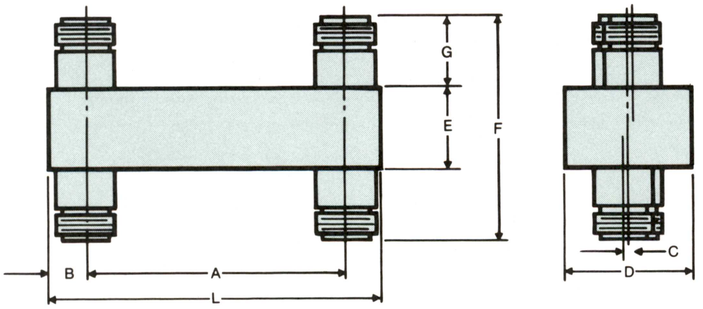
TEMLINE®
3-dB
HYBRIDS

FEATURES

- broadband performance
- 8 models covering 60-12,000 MHz
- rugged construction
- 90° phase differential between output ports
- type N female connectors standard





MATERIALS & FINISHES

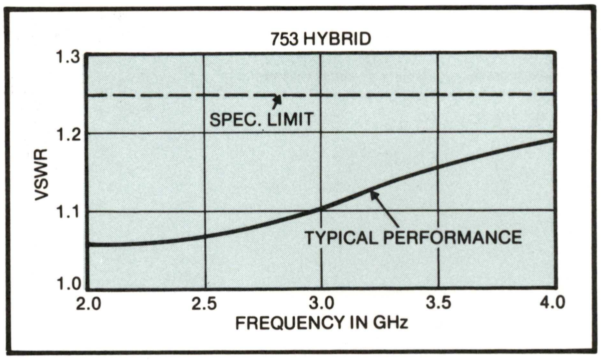
Fabricated in aluminum
Beryllium copper coaxial contacts
All metals silver-plated & rhodium-flashed
Body surfaces painted SAGE Hammertone Green
All SAGELINE materials & finishes to Govt. specs
Alternative materials & finishes available on special order

MECHANICAL DATA

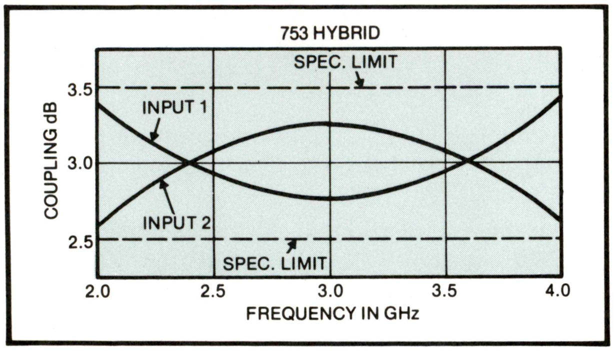
MODEL NUMBER	A		B		L		C		D		E		F		G	
	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in	cm
748	22.000	(55,880)	.344	(0,873)	22.688	(57,627)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
749	11.000	(27,940)	.344	(0,873)	11.688	(29,687)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
750	5.625	(14,287)	.344	(0.873)	6.313	(16,035)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
751	2.781	(7,063)	.344	(0,873)	3.469	(8,811)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
752	1.406	(3,571)	.344	(0,873)	2.938	(7,462)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
753	.813	(2,065)	.344	(0,873)	1.500	(3,810)	.109	(0,276)	1.375	(3,492)	.875	(2,222)	2.313	(5,875)	.719	(1,826)
754ND	.830	(2,108)	.330	(0,838)	1.500	(3,810)	.510	(1,295)	1.360	(3,454)	.750	(1,905)	2.040	(5,181)	.650	(1,651)
755	.830	(2,108)	.330	(0,838)	1.500	(3,810)	.340	(0,863)	1.200	(3,048)	.750	(1,905)	2.040	(5,181)	.650	(1,651)

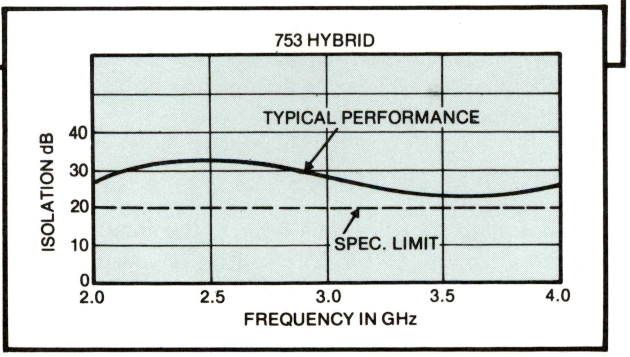
TEMLINE® HIGH POWER 3-dB QUADRATURE HYBRIDS

ELECTRICAL SPECIFICATIONS



MODEL NUMBER	FREQUENCY RANGE	COUPLING	MINIMUM ISOLATION	MAX. VSWR	MAX. INSERTION LOSS
748	60-125 MHz	3 dB ± 0.5 dB	30 dB	1.20	0.1 dB
749	125-250 MHz	3 dB ± 0.5 dB	20 dB	1.20	0.1 dB
750	250-500 MHz	3 dB ± 0.5 dB	20 dB	1.20	0.1 dB
751	500-1000 MHz	3 dB ± 0.5 dB	20 dB	1.25	0.1 dB
752	1000-2000 MHz	3 dB ± 0.5 dB	20 dB	1.25	0.1 dB
753	2000-4000 MHz	3 dB ± 0.5 dB	20 dB	1.25	0.1 dB
754ND	4000-8000 MHz	3 dB ± 0.5 dB	17 dB	1.40	0.3 dB
755	8000-12000 MHz	3 dB ± 0.5 dB	17 dB	1.50	0.3 dB





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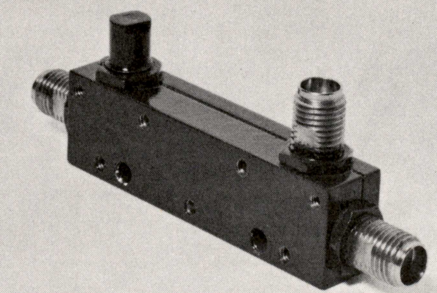
MINIATURE IN-LINE DIRECTIONAL COUPLERS C-750 SERIES

FEATURES

- −54°C to +125°C operational temperature range
- guaranteed to meet MIL-E-5400 Class 3
- milled & sealed aluminum housings ensure RFI & environmental shielding
- 6, 10, 20 & 30 dB standard coupling values ... others on request
- passivated stainless steel SMA connectors with interface per MIL-C-39012
- models from 0.5-18 GHz
- flexible design permits easy modification to meet special requirements



ACTUAL SIZE

CONSTRUCTION

Sage in-line miniature couplers use solid stripline construction techniques. Milled aluminum housings ensure complete environmental and RFI shielding, and epoxy sealing makes the units impervious to humidity and salt spray. These couplers have been computer-designed using Sage proprietary techniques to ensure low loss, low VSWR, and high directivity.

The coupler circuits are single-section and multi-section designs. They are precision etched on premium low loss dielectric circuit boards. Most of the lower frequency units use single-section designs in order to minimize overall lengths. The higher frequency units use 2-section and 3-section asymmetric coupler configurations in order to improve overall coupling flatness and to enable Sage to be conservative in its published specifications.

DEFINITION OF TERMS

The *coupling* specifications refer to the maximum allowable coupling range, and *include coupling flatness*. Example: model C754-10 coupling is specified as 10 ±0.75 dB from 4-8 GHz. The coupling over this bandwidth must remain between 9.25 dB and 10.75 dB.

Flatness specifies the maximum coupling variation within the frequency band. In the example above, if coupling varied from 9.6 dB to 10.2 dB, the total coupling variation would be 0.6 dB or ±0.3 dB, which is within the ±0.5 dB flatness specification. The coupling may vary by up to ±0.5 dB, but must remain within the 10±0.75 dB window.

Loss is the actual dissipated and reflected loss. It does *not* include coupling loss.

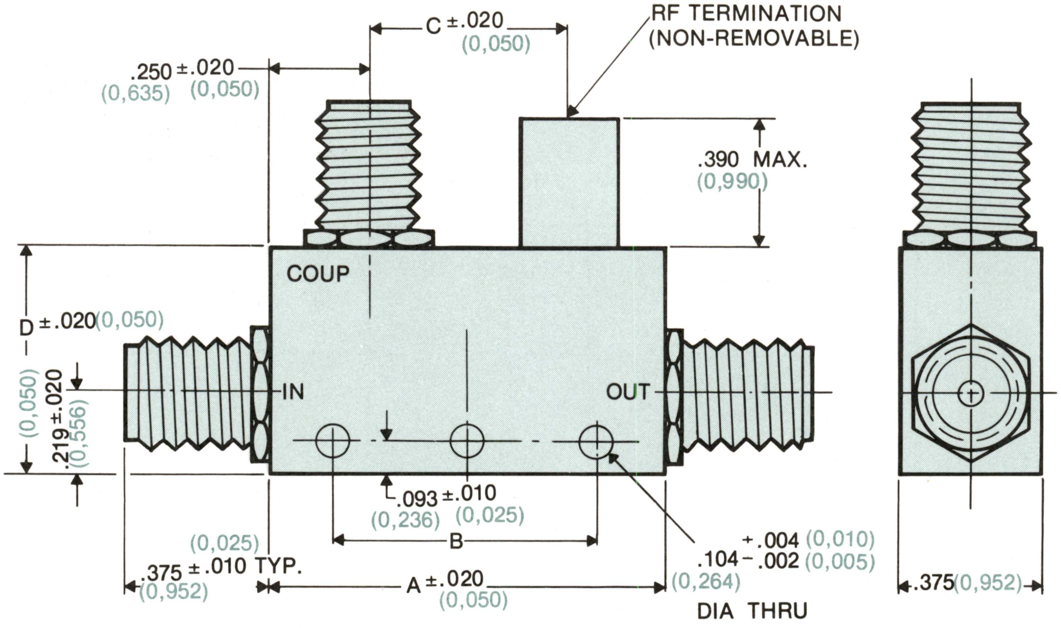
MINIATURE IN-LINE DIRECTIONAL COUPLERS
ELECTRICAL SPECIFICATIONS

							POWER HANDLING CAPABILITY			
MODEL NUMBER	FRE-QUENCY (GHz)	COUPLING (dB)	FLATNESS (dB)	MAXIMUM VSWR*	MAXIMUM LOSS (dB)	MINIMUM DIREC-TIVITY (dB)	AVERAGE INCIDENT (WATTS)	AVERAGE RE-FLECTED (WATTS)	PEAK (KW)	DERATE PER CURVE**
C751-6	.5-1	6±1	±.6	1.10	.15	25	50	2	3	A
C751-10	.5-1	10±1	±.75	1.10	.15	25	50	5	3	A
C751-20	.5-1	20±1	±.75	1.10	.15	25	50	50	3	A
C751-30	.5-1	30±1	±.75	1.10	.15	25	50	50	3	A
C752-6	1-2	6±1	±.6	1.15	.2	25	50	2	3	A
C752-10	1-2	10±1	±.75	1.15/1.10	.2	25	50	5	3	A
C752-20	1-2	20±1	±.75	1.15/1.10	.2	25	50	50	3	A
C752-30	1-2	30±1	±.75	1.15	.2	25	50	50	3	A
C752E-6	1.3-2.6	6±1	±.60	1.15	.2	24	50	2	3	B
C752E-10	1.3-2.6	10±1	±.75	1.15	.2	24	50	5	3	A
C752E-20	1.3-2.6	20±1	±.75	1.15	.2	24	50	50	3	A
C752E-30	1.3-2.6	30±1	±.75	1.15	.2	24	50	50	3	A
C753-6	2-4	6±1	±.6	1.15	.2	22	50	2	3	B
C753-10	2-4	10±1	±.75	1.15	.2	22	50	5	3	A
C753-20	2-4	20±1	±.75	1.15	.2	22	50	50	3	A
C753-30	2-4	30±1	±.75	1.15	.2	22	50	50	3	A
C753E-6	2.6-5.2	6±1	±.6	1.25	.25	20	50	2	3	B
C753E-10	2.6-5.2	10±1	±.75	1.25	.25	20	50	5	3	A
C753E-20	2.6-5.2	20±1	±.75	1.25	.25	20	50	50	3	A
C753E-30	2.6-5.2	30±1	±.75	1.25	.25	20	50	50	3	A
C754-6	4-8	6±.75	±.5	1.25	.25	18	50	2	3	B
C754-10	4-8	10±.75	±.5	1.25	.25	20	50	5	3	A
C754-20	4-8	20±.75	±.5	1.25	.25	20	50	50	3	A
C754-30	4-8	30±.75	±.5	1.25	.25	20	50	50	3	A
C754E-6	4.8-9.6	6±.75	±.5	1.27	.35	18	50	2	3	B
C754E-10	4.8-9.6	10±.75	±.5	1.27	.35	18	50	5	3	A
C754E-20	4.8-9.6	20±.75	±.5	1.27	.35	18	50	50	3	A
C754E-30	4.8-9.6	30±.75	±.5	1.27	.35	18	50	50	3	A
C755-6	7-12.4	6±1	±.5	1.3	.4	15	50	2	2	D
C755-10	7-12.4	10±1	±.5	1.3	.4	17	50	5	2	D
C755-20	7-12.4	20±1	±.5	1.25	.3	17	50	50	2	C
C755-30	7-12.4	30±1	±.5	1.25	.3	17	50	50	2	C
C756-6	12-18	6±1	±.5	1.35/1.4	.4	15	50	2	2	D
C756-10	12-18	10±1	±.5	1.35/1.4	.4	15	50	5	2	D
C756-20	12-18	20±1	±.5	1.35/1.4	.3	15	50	50	2	C
C756-30	12-18	30±1	±.5	1.35/1.4	.3	15	50	50	2	C
C756E-6	6.5-18	6±1	±.6	1.35/1.4	.4	15	50	2	2	D
C756E-10	6.5-18	10±1	±.75	1.35/1.4	.4	15	50	5	2	D
C756E-20	6.5-18	20±1	±.75	1.35/1.4	.3	15	50	50	2	C
C756E-30	6.5-18	30±1	±.75	1.35/1.4	.3	15	50	50	2	C

*Dual-value entries indicate primary/secondary VSWR

**See pages 190, 191, 192

MINIATURE IN-LINE DIRECTIONAL COUPLERS - MECHANICAL DATA


C ±.020 (0,050)
RF TERMINATION (NON-REMOVABLE)
.250 ±.020 (0,635) (0,050)
.390 MAX. (0,990)
COUP
D ±.020 (0,050)
IN
OUT
.219 ±.020 (0,556) (0,050)
.093 ±.010 (0,236) (0,025)
B
(0,025) .375 ±.010 TYP. (0,952)
A ±.020 (0,050)
.104 +.004 -.002 (0,010) (0,005) (0,264) DIA THRU
.375 (0,952)

MATERIALS & FINISHES

Housings: machined aluminum
Sealing: epoxy
Finish: Sage Hammertone Green paint

Connectors: SMA Female (standard), passivated stainless steel shells, interfaces per Mil-C-39012
Alternative connectors, materials & finishes available on special order

MODEL NUMBERS	CASE STYLE	FRE-QUENCY (GHz)	DIMENSIONS (SEE DRAWING)								WEIGHTS	
			A"	A (cm)	B"	B (cm)	C"	C (cm)	D"	D (cm)	Ounces	(Grams)
C-751-6, 10, 20, 30	A	.5-1	3.000	(7,620)	1.000	(2,540)	2.500	(6,350)	.550	(1,397)	1.3	37
C752-6, 10, 20	B	1-2	1.781	(4,523)	.937	(2,379)	1.281	(3,253)	.500	(1,270)	0.8	23
C752-30	C	1-2	1.781	(4,523)	.937	(2,379)	1.281	(3,253)	.550	(1,397)	0.9	26
C752E-6, 10, 20	D	1.3-2.6	1.396	(3,545)	.568	(1,442)	.896	(2,275)	.500	(1,270)	0.7	20
C752E-30	E	1.3-2.6	1.396	(3,545)	.568	(1,442)	.896	(2,275)	.550	(1,397)	0.8	23
C753-6, 10, 20	F	2-4	1.156	(2,936)	.343	(0,871)	.656	(1,666)	.500	(1,270)	0.6	17
C753-30	G	2-4	1.156	(2,936)	.343	(0,871)	.656	(1,666)	.550	(1,397)	0.7	20
C753E-6, 10, 20	H	2.6-5.2	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C753E-30	I	2.6-5.2	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	17
C754-6, 10, 20	H	4-8	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C754-30	I	4-8	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	17
C754E-6, 10, 20	H	4.8-9.6	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C754E-20, 30	I	4.8-9.6	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	17
C755-6	H	7-12.4	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C755-10, 20	I	7-12.4	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	17
C755-30	J	7-12.4	1.000	(2,540)	N/A	N/A	.500	(1,270)	.625	(1,587)	0.8	20
C756-6	H	12-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C756-10, 20	I	12-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	20
C756-30	J	12-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.625	(1,587)	0.8	23
C756E-6	H	6.5-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.500	(1,270)	0.6	17
C756E-10, 20	I	6.5-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.550	(1,397)	0.7	20
C756E-30	J	6.5-18	1.000	(2,540)	N/A	N/A	.500	(1,270)	.625	(1,587)	0.8	23

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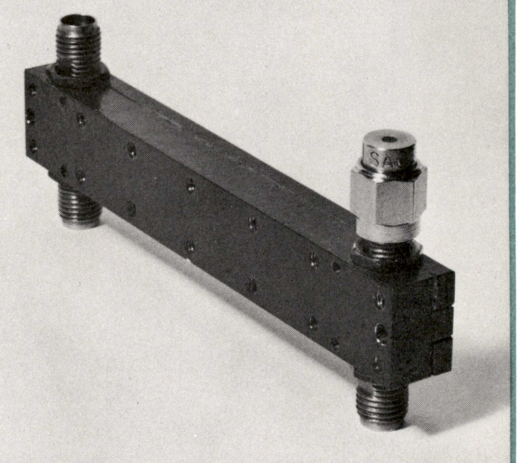
MINIATURE H-STYLE DIRECTIONAL COUPLERS D750 SERIES

FEATURES

- −54°C to +125°C operational temperature range
- guaranteed to meet MIL-E-5400 Class 3
- milled & sealed aluminum housings ensure RFI & environmental shielding
- 6, 10, 20 & 30 dB standard coupling values ... others on request
- passivated stainless steel SMA connectors with interface per MIL-C-39012
- models from 0.5-18 GHz
- flexible design permits easy modification to meet special requirements



ACTUAL SIZE

CONSTRUCTION

Sage in-line miniature couplers use solid stripline construction techniques. Milled aluminum housings ensure complete environmental and RFI shielding, and epoxy sealing makes the units impervious to humidity and salt spray. These couplers have been computer-designed using Sage proprietary techniques to ensure low loss, low VSWR, and high directivity.

The coupler circuits are single-section and multi-section designs. They are precision etched on premium low loss dielectric circuit boards. Most of the lower frequency units use single-section designs in order to minimize overall lengths. The higher frequency units use 2-section and 3-section asymmetric coupler configurations in order to improve overall coupling flatness and to enable Sage to be conservative in its published specifications.

DEFINITION OF TERMS

The *coupling* specifications refer to the maximum allowable coupling range, and *include coupling flatness*. Example: model D754-10R coupling is specified as 10±0.75 dB from 4-8 GHz. The coupling over this bandwidth must remain between 9.25 dB and 10.75 dB.

Flatness specifies the maximum coupling variation within the frequency band. In the example above, if coupling varied from 9.6 dB to 10.2 dB, the total coupling variation would be 0.6 dB or ±0.3 dB, which is within the ±0.5 dB flatness specification. The coupling may vary by up to ±0.5 dB, but must remain within the 10 ±0.75 dB window.

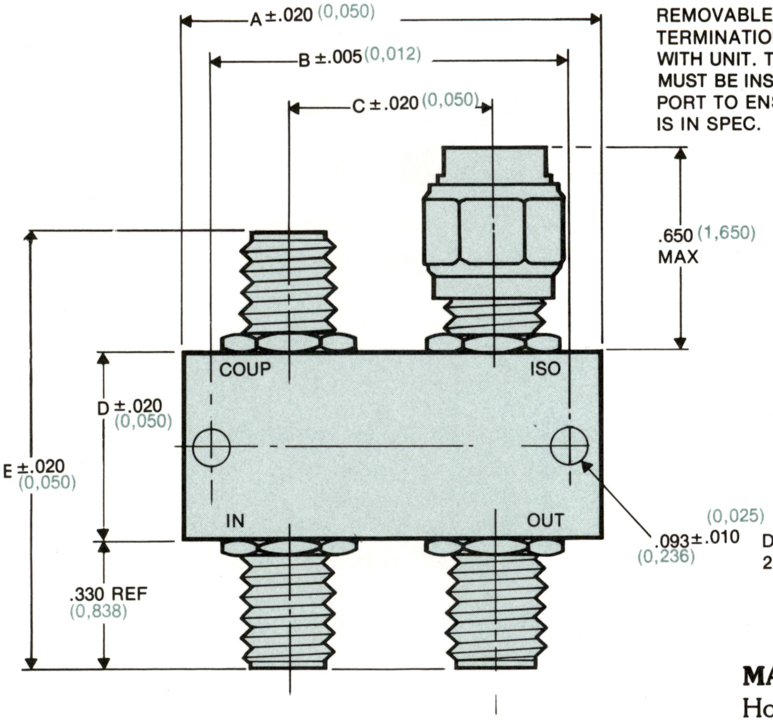
Loss is the actual dissipated and reflected loss. It does *not* include coupling loss.

MINIATURE H-STYLE DIRECTIONAL COUPLERS
ELECTRICAL SPECIFICATIONS

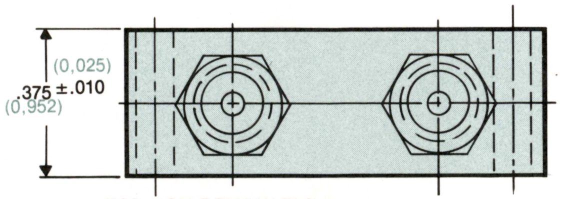
							POWER HANDLING CAPABILITY			
MODEL NUMBER	FRE-QUENCY (GHz)	COUPLING (dB)	FLATNESS (dB)	MAXIMUM VSWR	MAXIMUM LOSS (dB)	MINIMUM DIREC-TIVITY (dB)	AVERAGE INCIDENT (WATTS)	AVERAGE RE-FLECTED (WATTS)	PEAK (KW)	DERATE PER CURVE*
D751-6R	.5-1	6±1	±.6	1.10	.15	25	50	2	3	A
D751-10R	.5-1	10±1	±.75	1.10	.15	25	50	5	3	A
D751-20R	.5-1	20±1	±.75	1.10	.15	25	50	50	3	A
D751-30R	.5-1	30±1	±.75	1.10	.15	25	50	50	3	A
D752-6R	1-2	6±1	±.6	1.10	.2	25	50	2	3	A
D752-10R	1-2	10±1	±.75	1.10	.2	25	50	5	3	A
D752-20R	1-2	20±1	±.75	1.10	.2	25	50	50	3	A
D752-30R	1-2	30±1	±.75	1.10	.2	25	50	50	3	A
D752E-6R	1.3-2.6	6±1	±.6	1.15	.2	24	50	2	3	B
D752E-10R	1.3-2.6	10±1	±.75	1.15	.2	24	50	5	3	A
D752E-20R	1.3-2.6	20±1	±.75	1.15	.2	24	50	50	3	A
D752E-30R	1.3-2.6	30±1	±.75	1.15	.2	22	50	50	3	A
D753-6R	2-4	6±1	±.6	1.15	.25	22	50	2	3	B
D753-10R	2-4	10±1	±.75	1.15	.25	22	50	5	3	A
D753-20R	2-4	20±1	±.75	1.15	.25	22	50	50	3	A
D753-30R	2-4	30±1	±.75	1.15	.25	22	50	50	3	A
D753E-6R	2.6-5.2	6±1	±.6	1.20	.25	20	50	2	3	B
D753E-10R	2.6-5.2	10±1	±.75	1.20	.25	20	50	5	3	A
D753E-20R	2.6-5.2	20±1	±.75	1.20	.25	20	50	50	3	A
D753E-30R	2.6-5.2	30±1	±.75	1.20	.25	20	50	50	3	A
D754-6R	4-8	6±.75	±.5	1.25	.30	18	50	2	3	B
D754-10R	4-8	10±.75	±.5	1.25	.30	18	50	5	3	A
D754-20R	4-8	20±.75	±.5	1.25	.30	18	50	50	3	A
D754-30R	4-8	30±.75	±.5	1.25	.30	18	50	50	3	A
D754E-6R	4.8-9.6	6±.75	±.5	1.25	.35	18	50	2	3	B
D754E-10R	4.8-9.6	10±.75	±.5	1.25	.35	18	50	5	3	A
D754E-20R	4.8-9.6	20±.75	±.5	1.25	.35	18	50	50	3	A
D754E-30R	4.8-9.6	30±.75	±.5	1.25	.35	16	50	50	3	A
D755-6R	7-12.4	6±1	±.5	1.35	.40	15	50	2	2	D
D755-10R	7-12.4	10±1	±.5	1.35	.40	16	50	5	2	D
D755-20R	7-12.4	20±1	±.5	1.35	.40	16	50	50	2	C
D755-30R	7-12.4	30±1	±.5	1.35	.40	15	50	50	2	C
D756-6R	12-18	6±1	±.5	1.40	.50	15	50	2	2	D
D756-10R	12-18	10±1	±.5	1.40	.50	15	50	5	2	D
D756-20R	12-18	20±1	±.5	1.40	.50	15	50	50	2	C
D756-30R	12-18	30±1	±.5	1.40	.50	12	50	50	2	C
D756E-6R	7-18	6±1	±.6	1.40	.50	12	25	2	2	E
D756E-10R	7-18	10±1	±.75	1.40	.50	12	50	5	2	D
D756E-20R	7-18	20±1	±.75	1.40	.50	12	50	50	2	C
D756E-30R	7-18	30±1	±.75	1.40	.50	12	50	50	2	C

*See pages 190, 191, 192

MINIATURE H-STYLE DIRECTIONAL COUPLERS
MECHANICAL DATA



REMOVABLE SMA
TERMINATION IS SUPPLIED
WITH UNIT. THIS TERMINATION
MUST BE INSTALLED ON ISOLATED
PORT TO ENSURE THAT DIRECTIVITY
IS IN SPEC.



FOR NON-REMOVABLE
TERMINATION OMIT SUFFIX R FROM PART NUMBER.

MATERIALS & FINISHES

Housings: machined aluminum

Sealing: epoxy

Finish: Sage Hammertone Green paint

Connectors: SMA Female (standard), passivated stainless steel shells, interfaces per MIL-C-39012

Alternative connectors, materials & finishes available on special order

MODEL NUMBERS	CASE STYLE	FRE-QUENCY (GHz)	DIMENSIONS (SEE DRAWING)										WEIGHTS	
			A"	A (cm)	B"	B (cm)	C"	C (cm)	D"	D (cm)	E"	E (cm)	Ounces	Grams
D751-6, 10, 20R	A	.5-1	3.270	(8,305)	3.130	(7,950)	2.710	(6,883)	.500	(1,270)	1.160	(2,946)	1.4	40
D751-30R	F	.5-1	3.270	(8,305)	3.130	(7,950)	2.710	(6,883)	.550	(1,397)	1.210	(3,073)	1.5	43
D752-6, 10, 20R	B	1-2	1.841	(4,676)	1.701	(4,320)	1.281	(3,253)	.500	(1,270)	1.160	(2,946)	1.2	34
D752-30R	G	1-2	1.841	(4,676)	1.701	(4,320)	1.281	(3,253)	.550	(1,397)	1.210	(3,073)	1.3	37
D752E-6, 10, 20R	C	1.3-2.6	1.500	(3,810)	1.360	(3,454)	.940	(2,387)	.500	(1,270)	1.160	(2,946)	1.0	28
D752E-30R	H	1.3-2.6	1.500	(3,810)	1.360	(3,454)	.940	(2,387)	.550	(1,397)	1.210	(3,073)	1.1	31
D753-6, 10, 20R	D	2-4	1.195	(3,035)	1.055	(2,679)	.635	(1,612)	.500	(1,270)	1.160	(2,946)	0.5	14
D753-30R	I	2-4	1.195	(3,035)	1.055	(2,679)	.635	(1,612)	.550	(1,397)	1.210	(3,073)	0.6	17
D753E-6, 10, 20R	E	2.6-5.2	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D753E-30R	J	2.6-5.2	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D754-6, 10R	E	4-8	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D754-20, 30R	J	4-8	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D754E-6, 10R	E	4.8-9.6	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D754E-20, 30R	J	4.8-9.6	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D755-6R	E	7-12.4	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D755-10, 20R	J	7-12.4	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D755-30R	K	7-12.4	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.625	(1,587)	1.285	(3,263)	0.7	20
D756-6R	E	12-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D756-10, 20R	J	12-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D756-30R	K	12-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.625	(1,587)	1.285	(3,263)	0.7	20
D756E-6R	E	7-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.500	(1,270)	1.160	(2,946)	0.5	14
D756E-10, 20R	J	7-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.550	(1,397)	1.210	(3,073)	0.6	17
D756E-30R	K	7-18	1.060	(2,692)	.920	(2,336)	.500	(1,270)	.625	(1,587)	1.285	(3,263)	0.7	20

sage

LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

MINIATURE IN-LINE & H-STYLE DIRECTIONAL COUPLERS

POWER DERATING CURVES & NOTES

AVERAGE INCIDENT POWER & PEAK POWER

Curves A through E on the following two pages illustrate the maximum recommended average incident power and peak power for Sage In-line and H-style miniature couplers (C750 series and D750 series).

The *maximum recommended peak power* is based on RF voltage breakdown, and is a function of altitude. In high altitude and space environments, multipaction, which results from resonance of secondary electrons within the breakdown region, can result in voltage breakdown at fairly low RF field strengths. In addition to being a function of altitude, multipaction is also frequency-sensitive. The primary regions of breakdown are the SMA connector interface and the SMA connector-to-stripline junction. The family of curves (A through E) shows maximum recommended peak power at altitudes from sea level to 100,000 feet.

The maximum recommended average power is based on the coupling value, the directivity of the coupler, and the maximum power dissipation of the RF termination. In some cases, the average incident power at high altitudes is limited by RF breakdown (multipaction) rather than by RF power dissipation. This is illustrated on the curves where the average power curve intersects and follows the peak power curve.

The maximum recommended power ratings shown in curves A through E presume that all ports are terminated in 50 ohms, and that the couplers are mounted on metal plates or other heat sinks which are at ambient temperature.

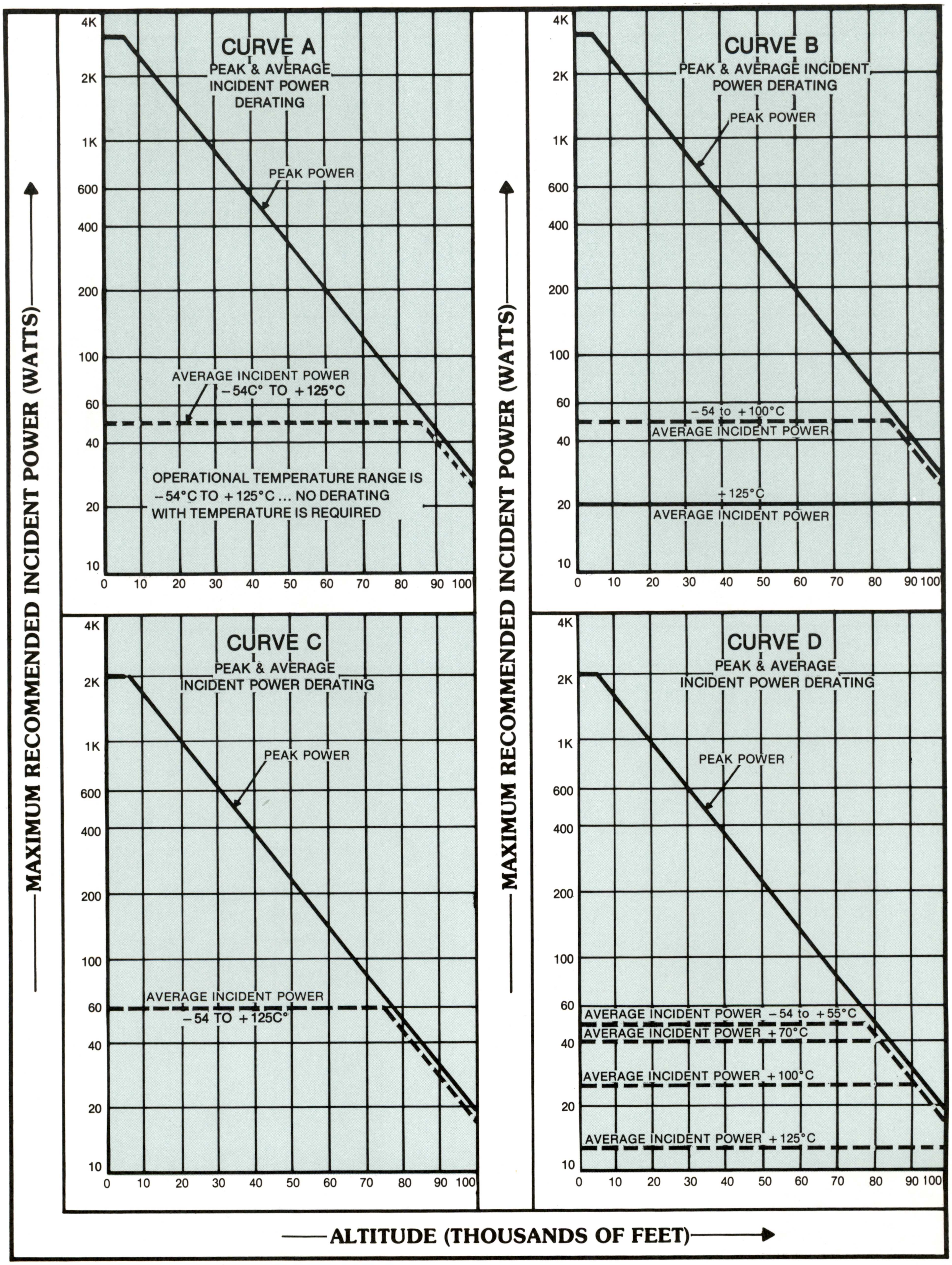
MAXIMUM REFLECTED POWER

Curves F and G illustrate the *maximum recommended reflected power* for Sage In-line and H-style miniature couplers (C750 series and D750 series). The maximum reflected power rating is based on the assumption that a signal is fed or reflected into the main line output port, and power is coupled into the RF termination. The maximum rating is a function of temperature and coupling.

POWER DISSIPATION IN TERMINATION

Curve H illustrates the maximum power dissipation of the RF termination as a function of temperature. You should refer to this curve when you drive the coupled output port with an RF source.

MINIATURE IN-LINE & H-STYLE DIRECTIONAL COUPLERS
POWER DERATING VS. ALTITUDE



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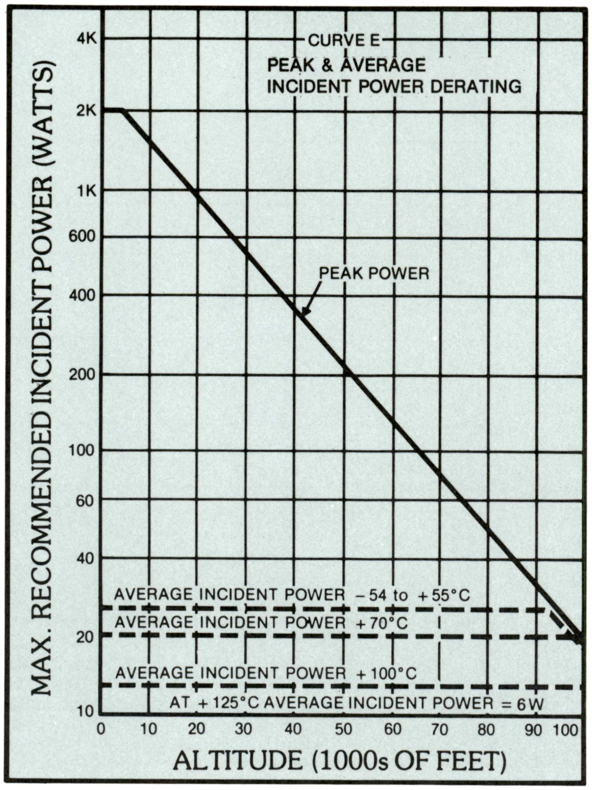
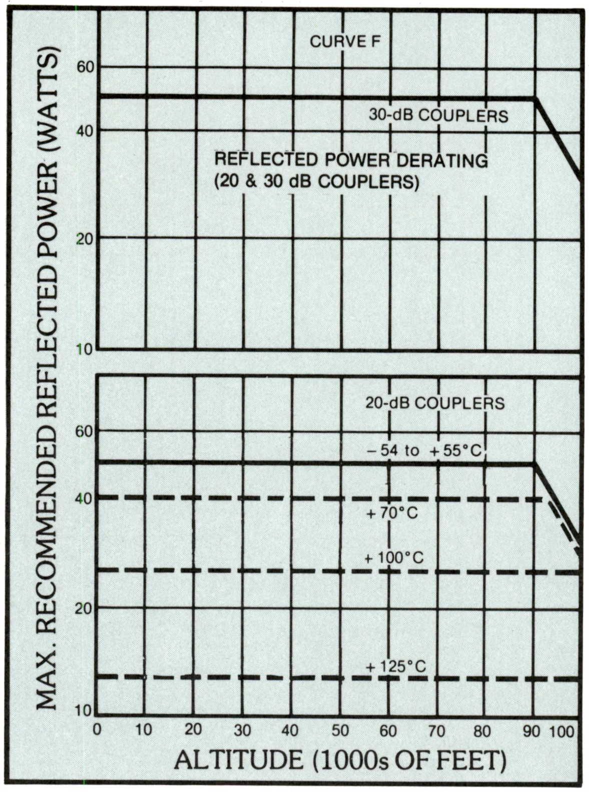
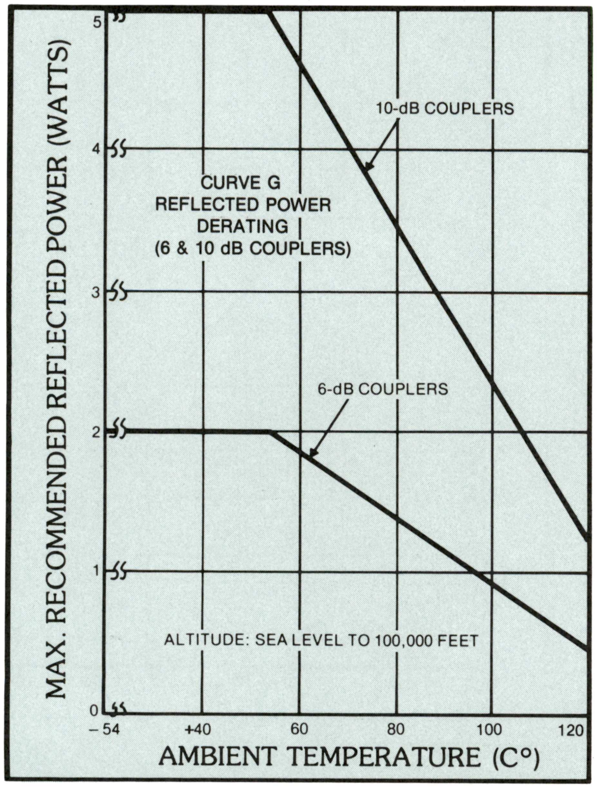
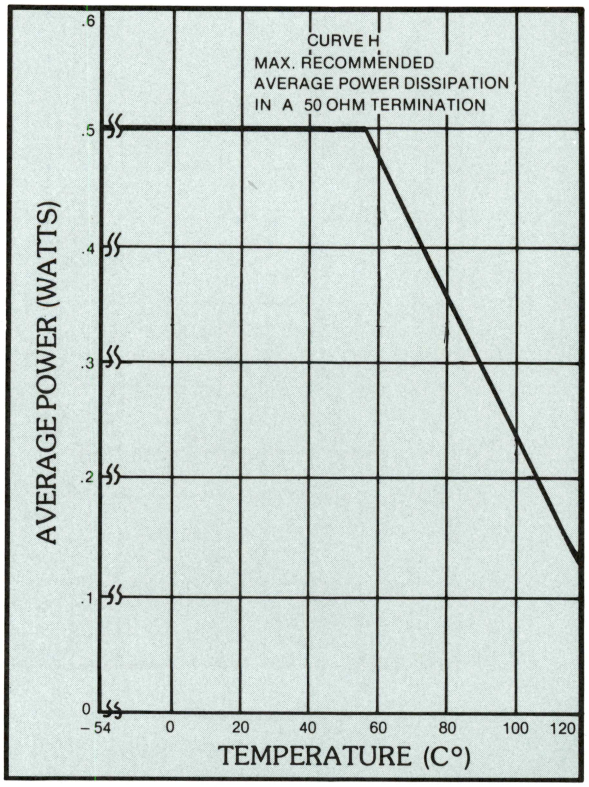
MINIATURE IN-LINE & H-STYLE DIRECTIONAL COUPLERS POWER DERATING VS. ALTITUDE (cont'd) & TEMPERATURE









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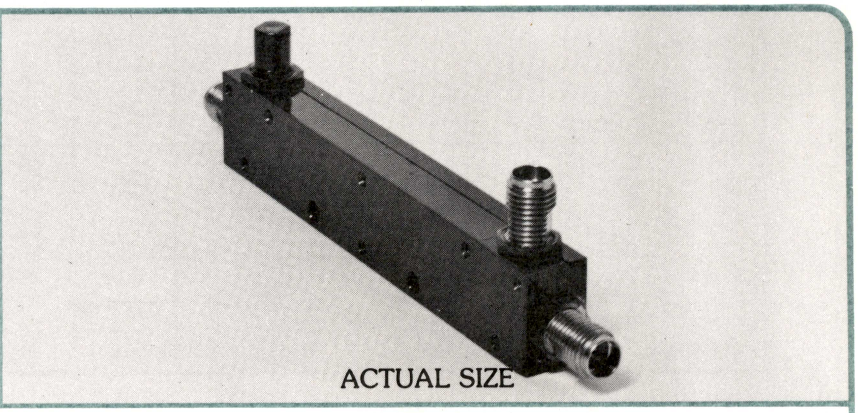
MINIATURE ULTRA-BROADBAND DIRECTIONAL COUPLERS

1-12.4 GHz, 1-18 GHz, 2-18 GHz BANDWIDTHS

6, 10, 16 & 20 dB COUPLING LEVELS

FEATURES

- up to 18:1 bandwidths
- small size
- guaranteed to meet MIL-E-5400 Class 2 (−54°C to +95°C, 0-70,000 feet)
- flat coupling

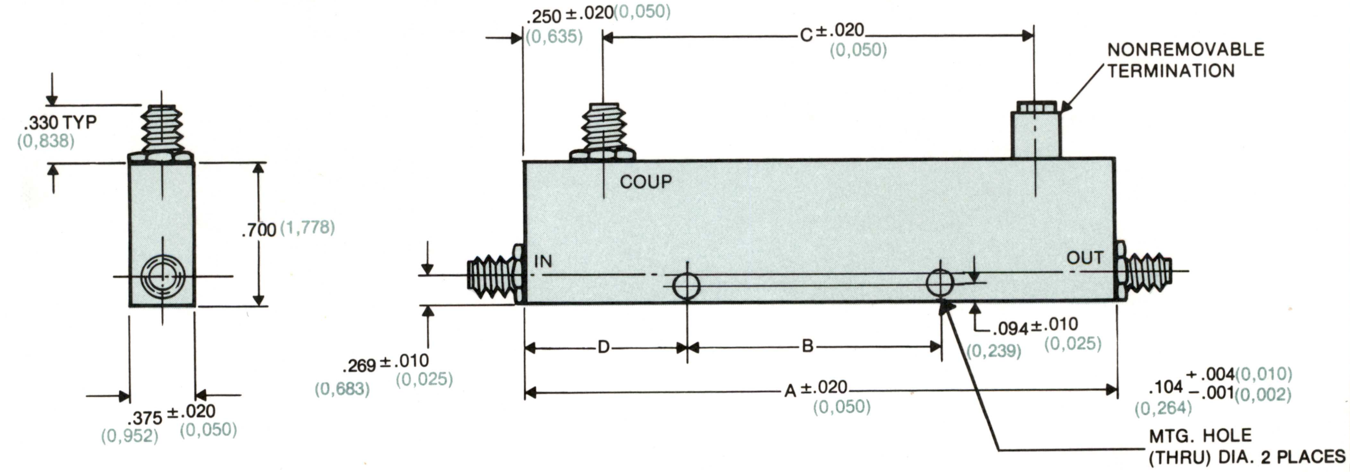


ACTUAL SIZE

DESCRIPTION

Sage ultra broadband miniature couplers are designed to operate reliably in both military and laboratory environments, and over bandwidths as broad as 18:1. These couplers use asymmetric continuously tapered coupled lines which are etched on low loss stripline dielectric. The circuits are enclosed in milled aluminum housings, and are epoxy sealed. Connectors are stainless steel SMA female with interfaces per MIL-C-39012. These couplers can be used in broadband ECM and measurement systems, or in reconfigurable narrowband systems where it would be impractical to change directional couplers when switching bands. The 16-dB couplers are intended for use in leveling circuits.

MECHANICAL DATA


.330 TYP
(0,838)
.700 (1,778)
.375 ±.020
(0,952) (0,050)
.250 ±.020(0,050)
(0,635)
C ±.020
(0,050)
NONREMOVABLE
TERMINATION
COUP
IN
OUT
.269 ±.010
(0,683) (0,025)
D
B
.094 ±.010
(0,239) (0,025)
A ±.020
(0,050)
.104 +.004(0,010) −.001(0,002)
(0,264)
MTG. HOLE
(THRU) DIA. 2 PLACES

CASE STYLE	A		B		C		D		WEIGHT	
	INCHES	(CM)	INCHES	(CM)	INCHES	(CM)	INCHES	(CM)	OUNCES	GRAMS
1	3.425	(8,699)	2.310	(5,867)	2.925	(7,429)	.557	(1,415)	2.1	(59.5)
2	1.975	(5,016)	.953	(2,421)	1.475	(3,746)	.511	(1,298)	1.4	(39.7)

MINIATURE ULTRA BROADBAND DIRECTIONAL COUPLERS
(Continued)

ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FRE-QUENCY (GHz)	COUPLING (dB)	FLATNESS (dB)	MAXIMUM VSWR		MAXIMUM LOSS (dB)	MINIMUM DIRECTIVITY (dB)		POWER HANDLING CAPABILITY**			CASE STYLE
				MAIN LINE	COUPLED LINE		TO 12 GHz	12 TO 18 GHz	AVERAGE INCIDENT (WATTS)	AVERAGE REFLECTED (WATTS)	PEAK (KW)	
C112-6	1-12.4	6 ± 1	± .5	1.30	1.40	.9	15	—	25	2	1.5	1
C112-10	1-12.4	10 ± 1	± .4	1.30	1.40	.7	15	—	25	5	1.5	1
C112-16	1-12.4	16 ± 1*	± .4	1.30	1.40	.7	15	—	25	25	1.5	1
C112-20	1-12.4	20 ± 1	± .4	1.30	1.40	.7	15	—	25	25	1.5	1
C118-6	1-18	6 ± 1	± .5	1.40	1.50	1.2	15	12	25	2	1.5	1
C118-10	1-18	10 ± 1	± .5	1.40	1.50	1.0	15	12	25	5	1.5	1
C118-16	1-18	16 ± 1*	± .5	1.40	1.50	.8	15	12	25	25	1.5	1
C118-20	1-18	20 ± 1	± .5	1.40	1.50	.8	15	12	25	25	1.5	1
C218-6	2-18	6 ± 1	± .5	1.35	1.45	1.0	20	17	25	2	1.5	2
C218-10	2-18	10 ± 1	± .5	1.35	1.45	.8	20	17	25	5	1.5	2
C218-16	2-18	16 ± 1*	± .4	1.35	1.45	.6	20	17	25	25	1.5	2
C218-20	2-18	20 ± 1	± .4	1.35	1.45	.6	20	17	25	25	1.5	2

*Reference to main line output port ... for use as a leveling coupler

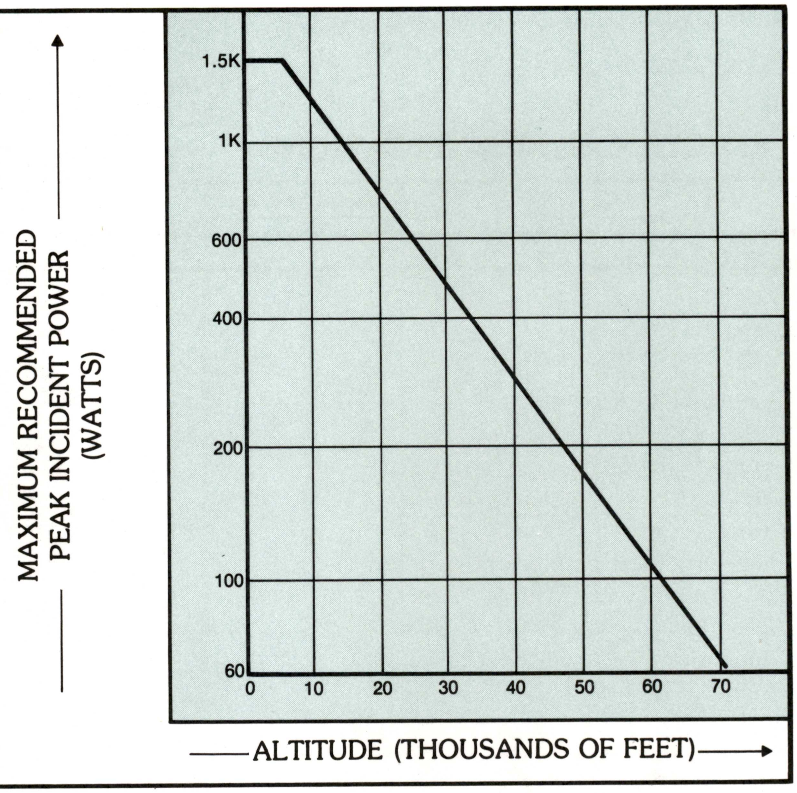
**Specified values assume that all ports are terminated in 50 ohms, and that the couplers are mounted on ambient temperature heat sinks at 0-5000 feet altitude. See specified curves for derating of peak and reflected power.

DEFINITION OF TERMS (Example: Model C118-10)

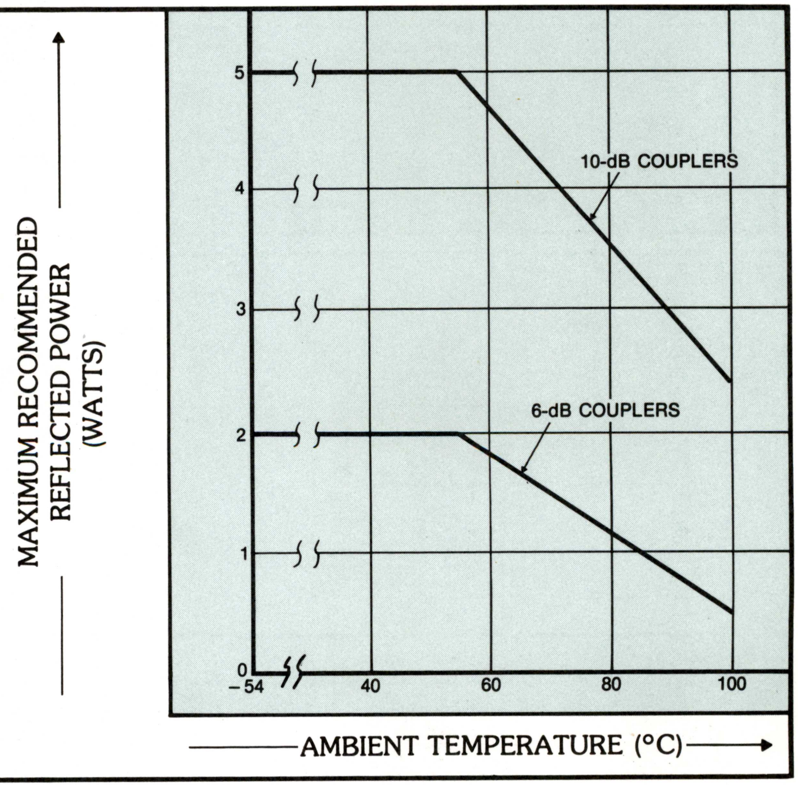
The *coupling* specifications refer to the maximum allowable coupling range, and *include coupling flatness*. A 10 ± 1 dB coupler must hold its coupling value between 9 dB and 11 dB. *Flatness* specifies the maximum coupling variation within the frequency band. If a 10 ± 1 dB coupler varied from 9.6 dB to 10.2 dB, the total coupling variation would be 0.6 dB or ±0.3 dB, which is within the ±0.5 dB flatness specification. The coupling may vary by up to ±0.5 dB, but must remain within the 10 ± 1 dB window. *Loss* is the actual dissipated and reflected loss. It does *not* include coupling loss.

MINIATURE ULTRA BROADBAND DIRECTIONAL COUPLERS (Continued)

PEAK POWER DERATING FOR ULTRA-BROADBAND DIRECTIONAL COUPLERS (NO DERATING REQUIRED FOR INCIDENT AVERAGE POWER)



MAXIMUM REFLECTED POWER DERATING CURVES FOR ULTRA-BROADBAND DIRECTIONAL COUPLERS (NO DERATING REQUIRED FOR 16-dB & 20-dB COUPLERS)



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3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

TEMLINE® OCTAVE-BAND HIGH POWER DIRECTIONAL COUPLERS

FEATURES

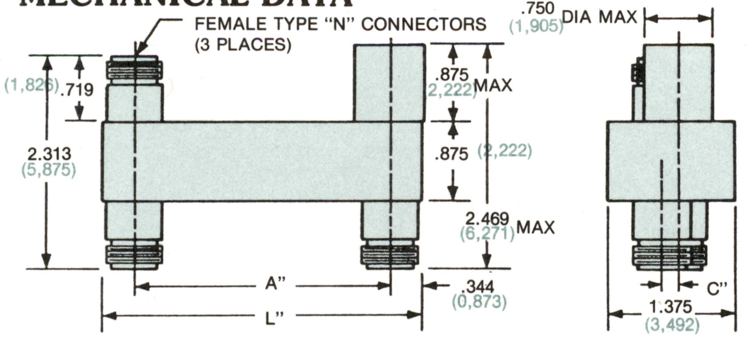
- octave band coverage
- low cost
- rugged construction
- built-in termination on secondary arm
- type N female connectors standard (alternative connectors on request)
- 6 models covering 60-4000 MHz
- minimum 18 dB directivity all models

SAGE
Laboratories, Inc.
NATICK, MASS.
MOD.
SER.

ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FREQUENCY RANGE (MHz)	COUPLING	MAXIMUM VSWR
748-3	60-125	3 dB ± 0.5 dB	1.20
749-3	125-250	3 dB ± 0.5 dB	1.20
750-3	250-500	3 dB ± 0.5 dB	1.20
751-3	500-1000	3 dB ± 0.5 dB	1.25
752-3	1000-2000	3 dB ± 0.5 dB	1.25
753-3	2000-4000	3 dB ± 0.5 dB	1.25

MECHANICAL DATA


FEMALE TYPE "N" CONNECTORS
(3 PLACES)
(1,826) .719
2.313
(5,875)
.875 (2,222) MAX
.875 (2,222)
2.469 (6,271) MAX
.344 (0,873)
A"
L"
.750 (1,905) DIA MAX
C"
1.375 (3,492)

MATERIALS & FINISHES

All models fabricated in aluminum
Coaxial contacts in beryllium copper
All metals silver-plated & rhodium-flashed
Body surfaces painted SAGE Hammertone Green
All SAGELINE materials & finishes to Govt. specs
Alternative materials & finishes supplied on special order

MODEL	FREQUENCY (MHz)	A"	A (cm)	L"	L (cm)	C"	C (cm)
748-3	60-125	22.0	(55,880)	22.688	(57,626)	.109	(0,277)
749-3	125-250	11.0	(27,940)	11.688	(29,686)	.109	(0,277)
750-3	250-500	5.63	(14,287)	6.313	(16,033)	.109	(0,277)
751-3	500-1000	2.78	(7,064)	3.468	(8,810)	.109	(0,277)
752-3	1000-2000	1.41	(3,571)	2.093	(5,318)	.109	(0,277)
753-3	2000-4000	.81	(2,063)	.500	(1,270)	.109	(0,277)

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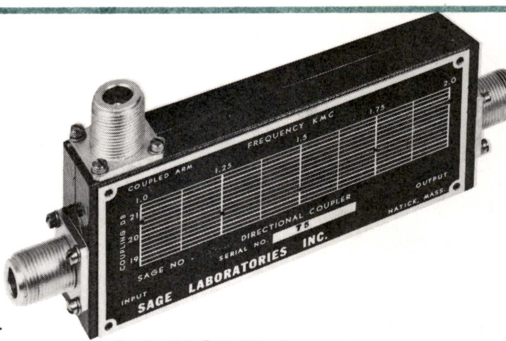
OCTAVE BAND HIGH POWER DIRECTIONAL COUPLERS

FEATURES

- octave band coverage
- low cost
- rugged construction
- built-in termination on secondary arm
- type N female connectors standard (alternative connectors available on request)
- high average power


COUPLED ARM
FREQUENCY KMC
1.0
1.25
1.5
1.75
2.0
COUPLING DB
21
20
19
DIRECTIONAL COUPLER
SAGE NO.
SERIAL NO.
OUTPUT
NATICK, MASS.
INPUT
SAGE LABORATORIES INC.

ALL MODELS

VSWR primary line	1.15 MAX.
VSWR secondary line	1.20 MAX.
Directivity	20 dB MIN.

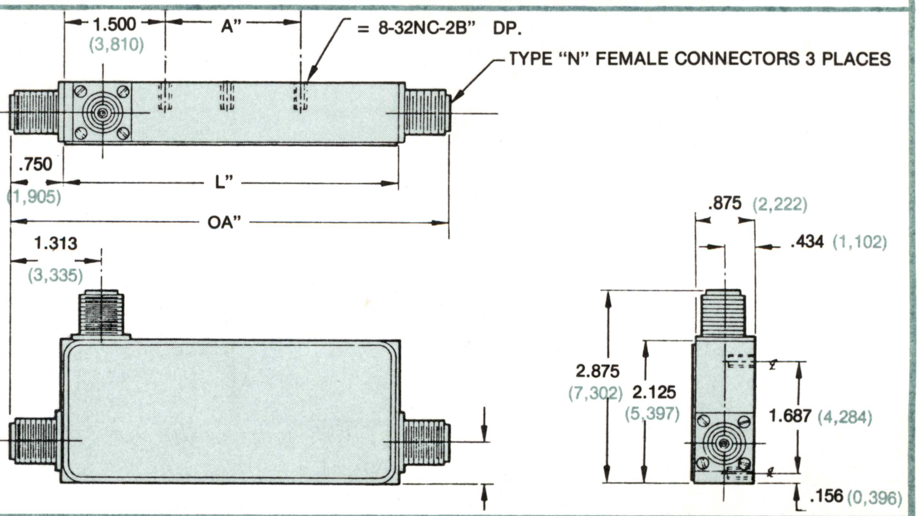
ELECTRICAL SPECIFICATIONS

MODEL NUMBER	FREQUENCY RANGE	COUPLING	POWER RATINGS FORWARD WATTS	POWER RATINGS REVERSE WATTS	POWER RATINGS PEAK KW
-10		10 dB ±1.0 dB	2000	50	10
783-20	2000-4000 MHz	20 dB ±1.0 dB	2000	500	10
-30		30 dB ±1.0 dB	2000	5000	10

MECHANICAL DATA

MATERIALS & FINISHES

Bodies fabricated in aluminum
Coaxial contacts (beryllium copper) & connectors (brass) silver-plated & rhodium-flashed
Body surfaces painted SAGE Hammertone Green
All SAGELINE materials & finishes to Govt. specs
Alternative materials & finishes supplied on special order


1.500
(3,810)
A"
= 8-32NC-2B" DP.
TYPE "N" FEMALE CONNECTORS 3 PLACES
.750
(1,905)
L"
OA"
1.313
(3,335)
.875 (2,222)
.434 (1,102)
2.875
(7,302)
2.125
(5,397)
1.687 (4,284)
.156 (0,396)

MODEL NUMBERS	OA"	OA (cm)	L"	L (cm)	A"	A (cm)	TOTAL NO. OF MOUNTING HOLES
783-10, 20, 30	6.5	(16,510)	5	(12,700)	2	(5,080)	4

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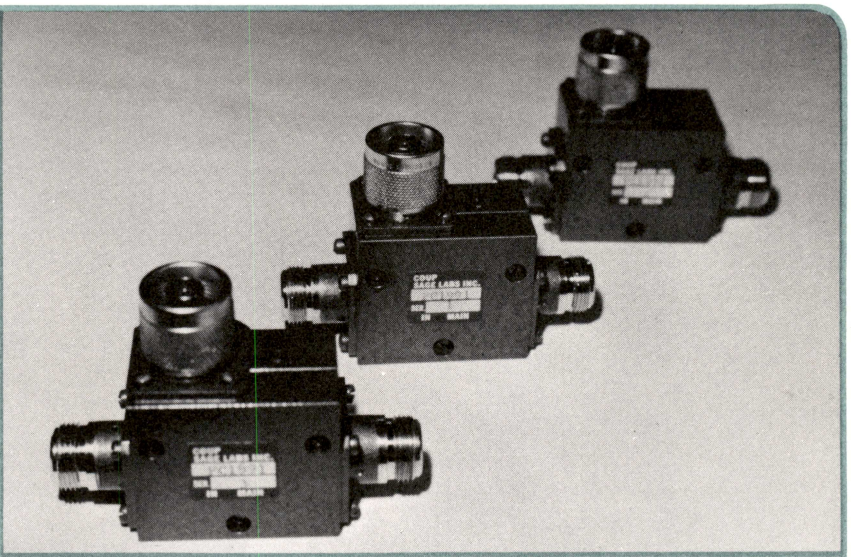
COMPACT COMMUNICATIONS BAND (3.7-4.2 GHz) DIRECTIONAL COUPLERS 7901 SERIES

FEATURES

- 3.7-4.2 GHz frequency range
- 20, 30, 40 & 50 dB coupling values
- high directivity
- low coupling ripple
- low VSWR
- compact

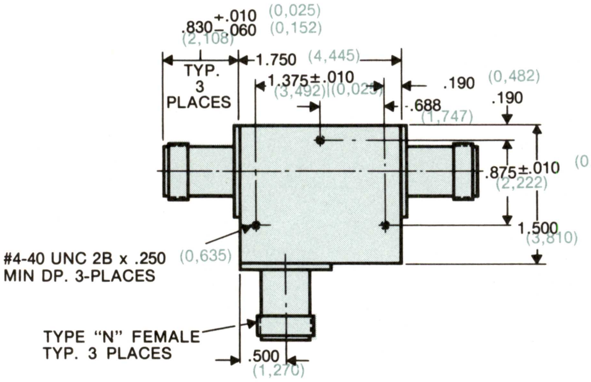


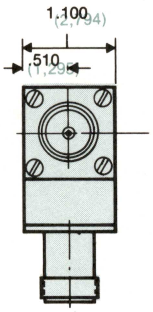
ELECTRICAL SPECIFICATIONS

Model Numbers	7901-20	7901-30	7901-40	7901-50
Maximum Coupling (dB)	20±0.5	30±0.75	40±1	50±1
Frequency Range	all models			3.7-4.2 GHz
Coupling Ripple (peak-to-peak)	all models			0.5 dB maximum
Maximum VSWR	all models			1.15
Minimum Directivity	all models			20 dB

Coupled line termination & dissipation rating for all models is 0.5 watts to 70°C; this derates to zero at 150°C.

MECHANICAL DATA


.830 +.010 −.060 (2,108) (0,025) (0,152)
TYP. 3 PLACES
1.750 (4,445)
1.375±.010 (3,492) (0,025)
.190 (0,482)
.688 (1,747)
.190
.875±.010 (2,222) (0,025)
1.500 (3,810)
#4-40 UNC 2B x .250 (0,635) MIN DP. 3-PLACES
TYPE "N" FEMALE TYP. 3 PLACES
.500 (1,270)


1.100 (2,794)
.510 (1,295)

MATERIALS & FINISHES

Material is aluminum, painted Sage Hammertone Green. Connector threads and mounting holes are unpainted. All SAGELINE materials & finishes are to government specifications.

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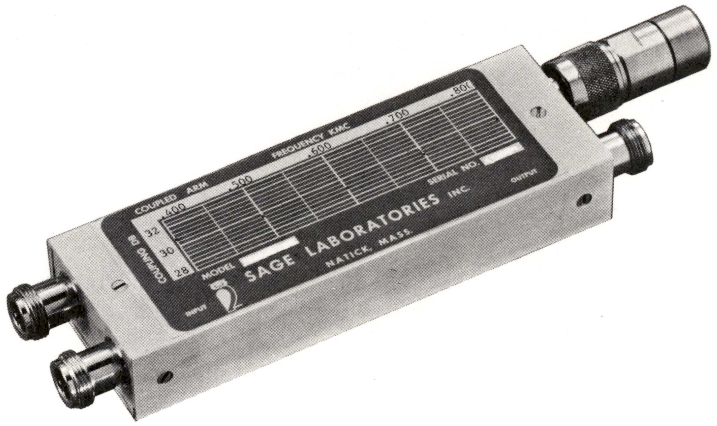
HIGH POWER OCTAVE BAND DIRECTIONAL COUPLERS 7800 SERIES

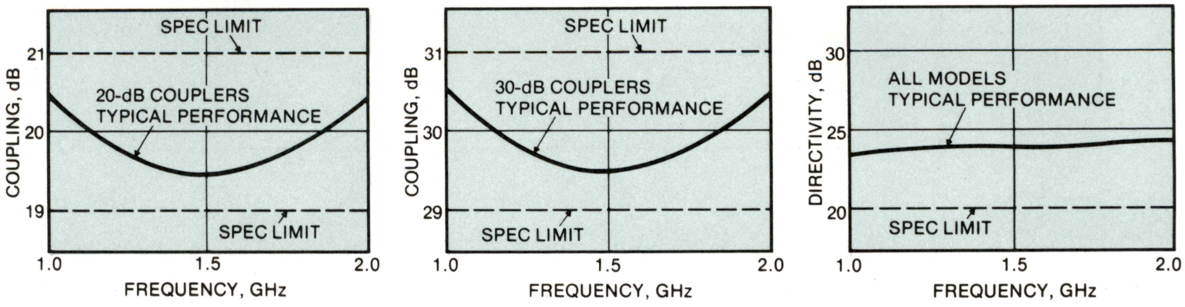
FEATURES

- octave-band coverage from 63 MHz to 2 GHz
- simple & reliable
- handle full type N coax power
- low loss
- 2 coupling values in each frequency band ... 20 & 30 dB


COUPLED ARM
FREQUENCY KMC
.400
.500
.600
.700
.800
COUPLING DB
32
30
28
MODEL
SERIAL NO.
SAGE LABORATORIES INC.
NATICK, MASS.
INPUT
OUTPUT

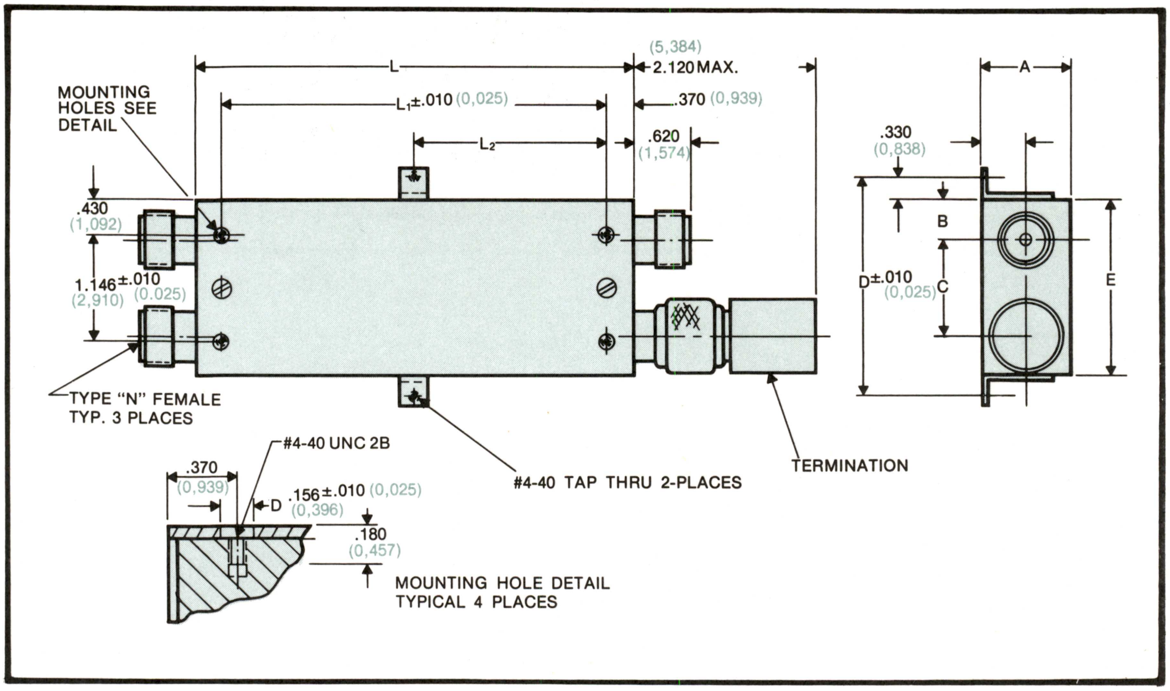
ELECTRICAL SPECIFICATIONS

Frequency Ranges	See MECHANICAL DATA table
Coupling	20 dB ± 1 dB and 30 dB ± 1 dB
Minimum Directivity	20 dB
Maximum Insertion Loss	0.1 dB
Maximum VSWR	1.25:1
Termination Power Rating (standard - higher power terminations can be supplied or substituted by the customer)	5 Watts



TYPICAL COUPLING & DIRECTIVITY PERFORMANCE FROM 1-2 GHz

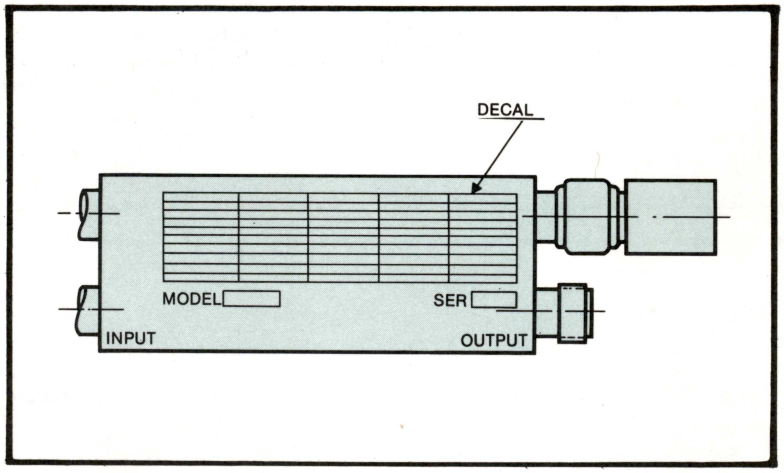
7800 SERIES DIRECTIONAL COUPLERS - MECHANICAL DATA


L
(5,384)
2.120 MAX.
L1±.010 (0,025)
.370 (0,939)
MOUNTING HOLES SEE DETAIL
L2
.620 (1,574)
.430 (1,092)
1.146±.010 (2,910) (0.025)
TYPE "N" FEMALE TYP. 3 PLACES
#4-40 UNC 2B
.370 (0,939)
D .156±.010 (0,025) (0,396)
.180 (0,457)
MOUNTING HOLE DETAIL TYPICAL 4 PLACES
#4-40 TAP THRU 2-PLACES
TERMINATION
.330 (0,838)
A
B
C
D±.010 (0,025)
E

MODEL NUMBER	FREQUENCY (MHz)	DIMENSIONS							
		L"	L (cm)	L_1"	L_1 (cm)	L_2"	L_2 (cm)	A"	A (cm)
7800-20	250-500	8.94	(22,707)	8.20	(20,828)	N.A.	NO TAB	1.27	(3,225)
7801-20	63-125	31.56	(80,162)	30.82	(78,282)	15.41	(39,141)	1.27	(3,225)
7802-20	125-250	16.56	(42,062)	15.82	(40,182)	N.A.	NO TAB	1.27	(3,225)
7803-20	210-420	10.44	(26,517)	9.70	(24,638)	N.A.	NO TAB	1.27	(3,225)
7810-20	500-1000	5.34	(13,563)	4.60	(11,684)	N.A.	NO TAB	1.27	(3,225)
7820-20	1000-2000	3.36	(8,534)	2.61	(6,639)	N.A.	NO TAB	1.27	(3,225)
7800-30	250-500	9.23	(23,444)	8.49	(21,556)	N.A.	NO TAB	1.00	(2,540)
7801-30	63-125	31.56	(80,162)	30.82	(78,282)	15.41	(39,141)	1.00	(2,540)
7802-30	125-250	16.56	(42,062)	15.82	(40,182)	N.A.	NO TAB	1.00	(2,540)
7803-30	210-420	10.72	(27,228)	9.99	(25,361)	N.A.	NO TAB	1.00	(2,540)
7810-30	500-1000	5.39	(13,690)	4.65	(11,811)	N.A.	NO TAB	1.00	(2,540)
7820-30	1000-2000	3.42	(8,686)	2.68	(6,807)	N.A.	NO TAB	1.00	(2,540)

OPTIONS

Units in the 7800 coupler series can be supplied in octave-bands other than those shown above, within the range from 63-2000 MHz. There is a nominal additional charge for special band units.



MATERIALS & FINISHES

Bodies & connectors fabricated from aluminum. Connectors chrome-plated. Bodies painted Sage Hammertone Green. All SAGELINE materials & finishes to Government specs. Alternative materials & finishes on special order.

DIMENSIONS								WEIGHTS	
B"	B (cm)	C"	C (cm)	D"	D (cm)	E"	E (cm)	OUNCES	GRAMS
.660	(1,676)	1.07	(2,717)	3.080	(7,823)	2.42	(6,146)	28	793.8
.660	(1,676)	1.06	(2,693)	3.080	(7,823)	2.42	(6,146)	89	2523.15
.660	(1,676)	1.06	(2,693)	3.080	(7,823)	2.42	(6,146)	47	1332.45
.660	(1,676)	1.06	(2,693)	3.080	(7,823)	2.42	(6,146)	31	878.85
.660	(1,676)	1.10	(2,794)	3.080	(7,823)	2.42	(6,146)	21	595.35
.660	(1,676)	1.14	(2,895)	3.080	(7,823)	2.42	(6,146)	14	396.90
.440	(1,117)	1.10	(2,794)	2.706	(6,873)	2.00	(5,080)	24	680.40
.440	(1,117)	1.10	(2,794)	2.706	(6,873)	2.00	(5,080)	82	2324.70
.440	(1,117)	1.10	(2,794)	2.706	(6,873)	2.00	(5,080)	44	1247.40
.440	(1,117)	1.10	(2,794)	2.706	(6,873)	2.00	(5,080)	28	793.80
.440	(1,117)	1.10	(2,794)	2.706	(6,873)	2.00	(5,080)	14	396.90
.440	(1,117)	1.15	(2,921)	2.706	(6,873)	2.00	(5,080)	9	55.15

POWER HANDLING NOTES

Our 7800 series couplers operate reliably to the full power handling capability of type N systems. The isolated port termination shown is a standard 5-watt type N part. This can easily be replaced with a higher power termination if your system requirements so dictate.

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APPLICATION NOTES HYBRIDS & COUPLERS

GENERAL.

In the 8-page portion of this Hybrid & Coupler section which is devoted to WIRELINE, a number of hybrid and coupler applications are described and illustrated. These application notes apply equally well to the other Sage quadrature hybrids and couplers.

DIRECTIONAL COUPLER APPLICATIONS

In this section, several microwave circuits that require directional couplers are discussed. Because the quadrature hybrid has so many applications, it will be considered separately. The advantages of integrating couplers with other devices are discussed, and actual circuits and test results are presented.

Microwave Circuits Employing Couplers

Figure 1 shows a coupler used for power monitoring. This is one of the most common coupler applications. A power bridge is connected to the auxiliary output to monitor the main line power. In this circuit, the power bridge is permanently connected so that the main line power is monitored continuously without breaking into the main line. In high power applications, this circuit is used almost exclusively to monitor main line power.

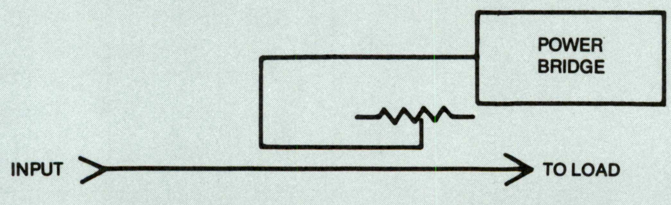


FIGURE 1 - ABSOLUTE POWER MONITOR

When possible, it is advisable to choose a value of coupling so that the power into the power bridge is in the 1mW to 10mW range (i.e. within the range of highest accuracy of most microwave power bridges).

Example: Main line power varies from 30 watts average to 100 watts average.
What value of coupler is required if a power bridge is available which measures up to 10mW? The required coupling is determined as follows:

100 watts is +50 dBm (50 dB greater than 1 mW)
10mW is +10 dBm
Answer: C = +50 − (+10) = 40dB

APPLICATION NOTES - HYBRIDS & COUPLERS (Continued)

Figure 2 shows another type of power monitor application, where the auxiliary output is connected to a diode detector, which in turn is connected to a D.C. meter or other direct current indicator. Power to the diode is normally below 10mW to prevent diode burn-out, and because most diodes saturate above this power level. The diode rectifies the coupled RF power and produces a D.C. current that is proportional to the RF power.

This simple device has many possible applications, among them the following:

(1) The meter can be calibrated in terms of main line power so that it indicated the approximate magnitude of the main line power at all times.

(2) The D.C. output can be connected to a relay to activate or de-activate another device when power is in the main line.

(3) Figure 3 shows how two coupler-diode detectors can be connected in a system to provide arc protection for a power tube.

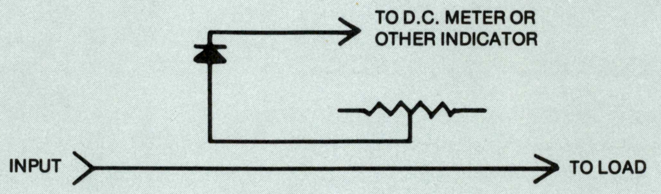


FIGURE 2 - RF-TO-D.C. CONVERSION. A SIMPLE POWER MONITOR

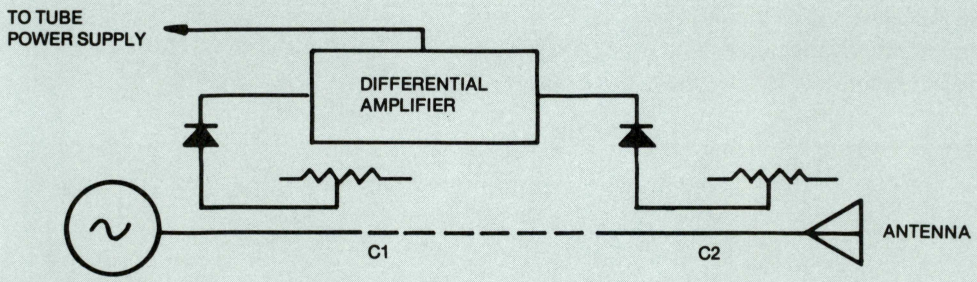


FIGURE 3 - ARC PROTECION FOR A POWER TUBE
USING TWO POWER-DETECTORS

The principle of operation is as follows:

If the power levels at C1 and C2 differ by a pre-determined value (e.g. if C2 detects no power), the differential amplifier output will shut off the D.C. power to the tube. If an arc occurs in the main line between C1 and C2, the switching circuit can be made to switch faster than the speed at which the arc can travel back to the tube. The RF power is shut down and the arc is extinguished before it can damage the tube.

APPLICATION NOTES - HYBRIDS & COUPLERS (Continued)

In some applications, where it is important to match a source to a load (e.g. for precision attenuation measurements), a directional coupler can be used instead of attenuators or isolators. This is especially true at the higher microwave frequencies. At X-band, for example, it may be necessary to keep the source VSWR below 1.25:1. An isolator or attenuator that satisfies this requirement may not be available; however, if a directional coupler is available with a match better than 1.25:1, it can be used as an attenuator as shown in Figure 4 to give the required source match.

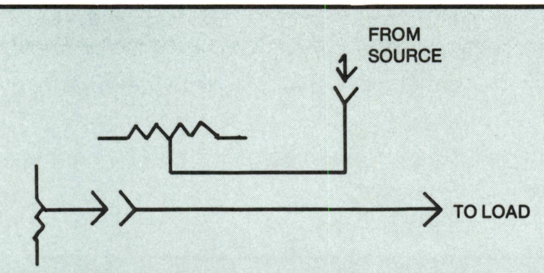


FIGURE 4 - SOURCE-TO-LOAD MATCH USING
A DIRECTIONAL COUPLER AS AN ATTENUATOR

Figure 5 shows a directional coupler and diode detector connected in a microwave mixer configuration. In this typical configuration, looking from the L.O. source, the diode is connected to the coupled output. Looking from the RF source, the diode is connected to the main line output. There is a good reason for this choice. In most mixers, it is necessary to minimize the conversion loss (or noise figure). Only by connecting the L.O. and R.F. as shown,

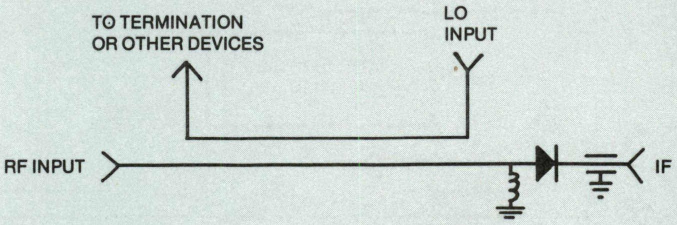


FIGURE 5 - SINGLE DIODE MIXER

will the lowest possible conversion loss be obtained (unless the coupler is a 3 dB coupler.)

Assume that 1mW of L.O. power is required to drive the diode and that a 10 dB coupler is available. In order to satisfy the 1mW power requirement, 10mW of L.O. power is required into the coupler L.O. input. Because a 10 dB coupler has 0.45 dB insertion loss through the main line, this R.F. loss through the coupler is included in determining the overall conversion loss of the mixer. If the L.O. and R.F. ports were interchanged, the mixer conversion loss would be 9.55 dB higher (the difference between 10 dB and 0.45 dB). In this case, only slightly greater than 1mW of L.O. power is required.

The following are the advantages of a single diode (single ended) mixer.

(1) Usually the cost is lower than for a balanced mixer.

(2) The L.O. power not coupled to the diode can be put to other uses.

APPLICATION NOTES - COUPLERS & HYBRIDS (Continued)

The disadvantages (relative to a balanced mixer) are as follows.

(1) A single diode mixer does not cancel L.O. noise. High noise figure can be expected unless L.O. source is extremely stable and noise-free.

(2) More L.O. power is required than in a balanced mixer.

(3) Conversion loss is higher than in a balanced mixer because of the coupler insertion loss.

(4) When the diode burns out, the device has no output; whereas, in a balanced mixer, if one diode burns out, system performance will degrade but the system will still operate.

The last three circuits to be discussed are used in most modern microwave measuring systems.

Figure 6 shows a method for leveling a microwave source. Without leveling, it is common to expect as much as 10 dB variation in output power over an octave band from a typical microwave source. With a well-designed leveler circuit, this variation can be lowered to ±0.5 dB. The circuit performs the following functions. A portion of the microwave power from the source is coupled to the diode detector. The rectified current from the detector is connected to the power supply circuitry so that for low output power the tube's driving voltage is given a boost and for high output power the driving voltage is turned down. The result is a lower output power than normal at some frequencies and an increase in output power at other frequencies.

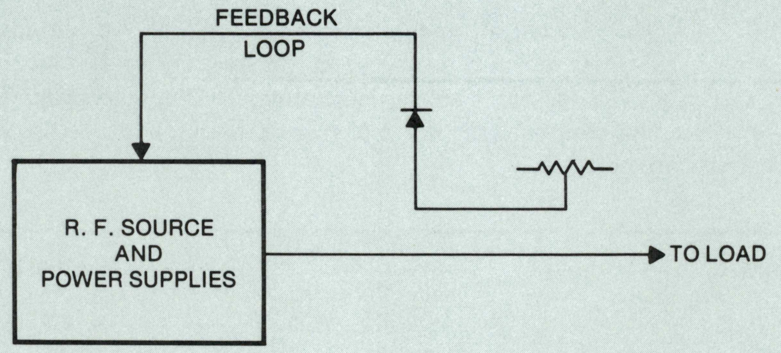


FIGURE 6
COUPLER-DETECTOR CONNECTED IN A FEEDBACK LOOP TO LEVEL A MICROWAVE SOURCE

APPLICATIONS OF THE 3 dB QUADRATURE HYBRID

Because of the 90° phase difference and the equal power division at the two output ports, the symmetrical 3 dB coupler lends itself to many unique applications. Figure 7a shows a hybrid with short-circuits on the output arms. With equal power split to the outputs, all the power is reflected out through the isolated arm, and the input port is matched. For an unbalanced condition in which the power levels to the short-circuits are unequal, some of the power will be reflected back to the input port, and the device insertion loss will increase. Theoretically, the performance of the device is the same if the short-circuits are removed and the output arms are open circuited. In practice, however, short-circuits perform better because an open-circuited line has a finite amount of loss due to radiation. Also, open-circuited lines are not shielded completely from external signals.

APPLICATION NOTES - COUPLERS & HYBRIDS (Continued)

In Figure 7b, the short-circuited hybrid is shown with variable short-circuits. If L1 = L2, the device is a low loss variable phase-shifter with a matched input. The absolute phase-shift through the device is limited only by the physical limitations of L1 and L2. If L1 ≠ L2, the device can be used as a variable mismatch, and can range anywhere from a perfect match to a perfect open or short circuit.

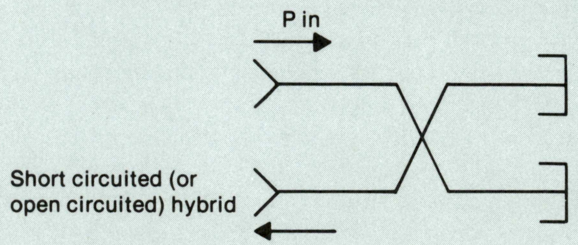


FIGURE 7 (a)

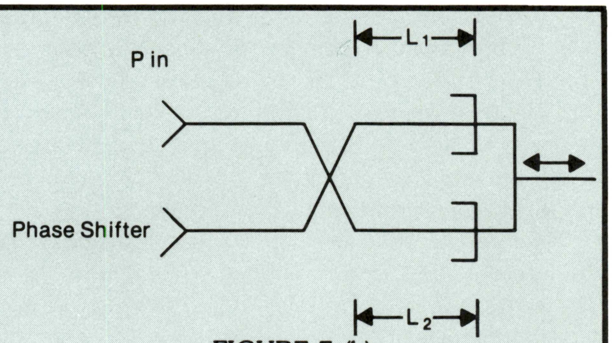


FIGURE 7 (b)

Figure 8 shows two hybrids connected in tandem. (Now we begin to see the advantage of having both outputs on the same surface.) As indicated in Figure 8, for frequencies at which the coupled lines are odd multiples of $\lambda/4$($\lambda/4$, 3 $\lambda/4$, etc.), all the input power will couple diagonally to the output port. For frequencies at which the coupled lines are multiples of $\lambda/2$($\lambda/2$, λ , $3\lambda/2$, etc.), all the input power is coupled to the auxiliary port.

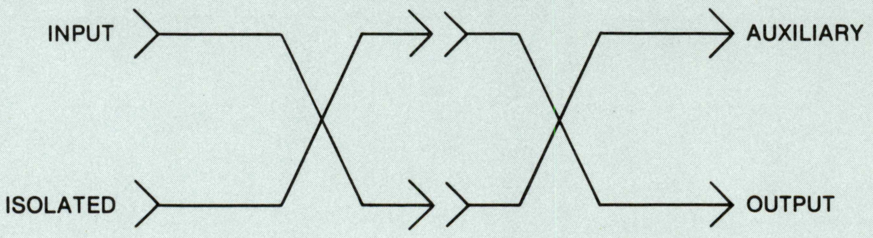


FIGURE 8 - TWO HYBRIDS IN TANDEM

Figures 9 and 10 show two practical applications of this tandem hybrid, which perform a diplexing function (that is, separate or combine two frequencies) in a mixer and in an upconverter. In the mixer circuit of Figure 9(a), each hybrid is $\lambda/4$ long at the L.O. frequency. The R.F. may be injected into the circuit as shown, or may be brought in with the L.O. The I.F. path from the diode is a D.C. path. An I.F. as high as ½ the L.O. can be used with no degradation in mixer performance. Figure 9(b) shows a Sage Model F6128-5 diplexer, which uses SAGE Laboratories' patented WIRELINE^{TM} technique. In this diplexer, the L.O. band si 1.7 — 4.2 GHz and the I.F. can be as high as 1000 MHz. The L.O. to I.F. isolation can be as high as 20 to 25 dB: this depends on the match of the diode.

APPLICATION NOTES - COUPLERS & HYBRIDS (Continued)

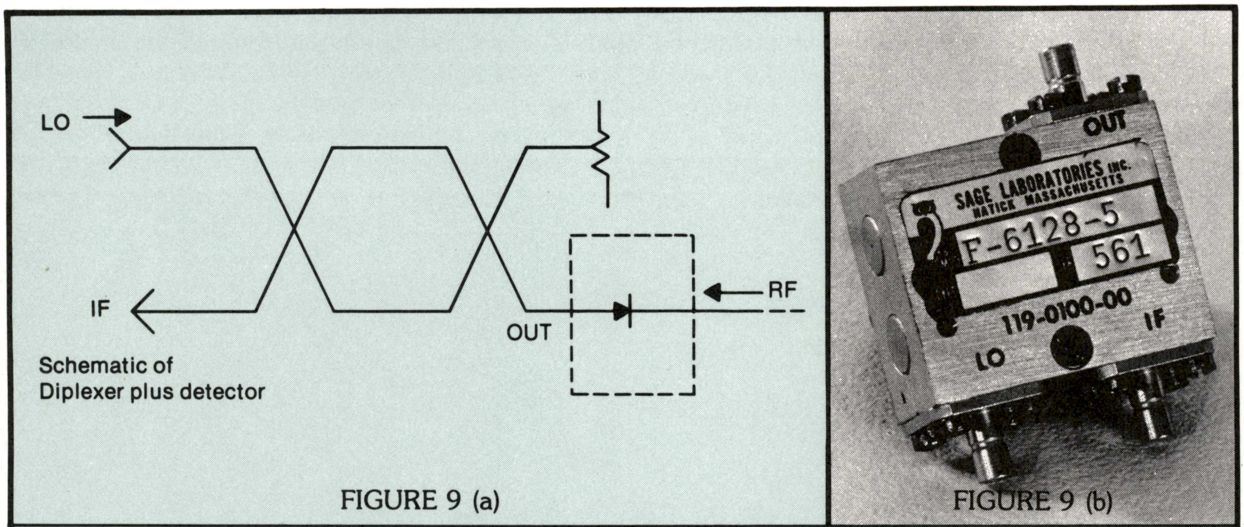

LO
IF
OUT
RF
Schematic of
Diplexer plus detector
OUT
SAGE LABORATORIES INC.
NATICK MASSACHUSETTS
F-6128-5
561
119-0100-00
LO
IF

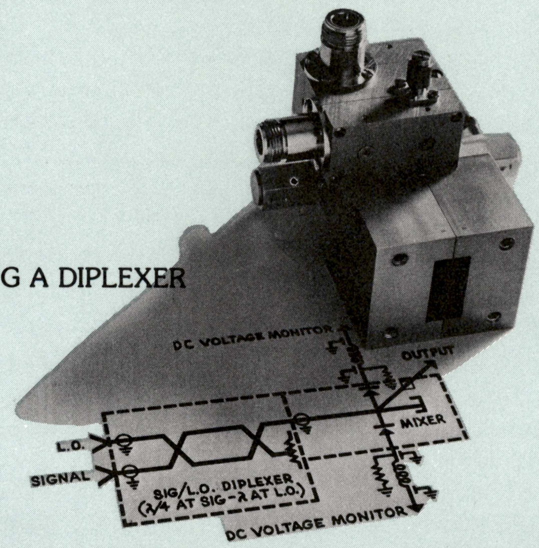
FIGURE 9 (a)

FIGURE 9 (b)

FIGURE 9 - DIPLEXER FOR A MIXER APPLICATION

In Figure 10, a diplexer is used in a frequency up-converter. Note that the diplexer makes use of both conditions of Figure 8. The lengths of the coupled lines are λ /4 at the signal frequency and λ at the L.O. frequencies. Signal and L.O. frequencies are combined in a balanced mixer, and the output (sum of L.O. and signal) is connected to the waveguide output.

FIGURE 10
HIGH PERFORMANCE UP-CONVERTER UTILIZING A DIPLEXER


DC VOLTAGE MONITOR
OUTPUT
MIXER
L.O.
SIGNAL
SIG/L.O. DIPLEXER
(λ/4 AT SIG - λ AT L.O.)
DC VOLTAGE MONITOR

A variable attenuator design is shown in Figure 11. This circuit has the two hybrids in tandem with a matched variable phase-shifter inserted in one interconnecting line. All the input power will couple to the two output arms. The power to either output can be varied from zero to total power transfer by changing the short-circuit position. In effect, the device is a variable attenuator. The attenuator's power capability is limited only by that of the hybrids. Therefore, this can be a high power attenuator if the hybrids are so designed.

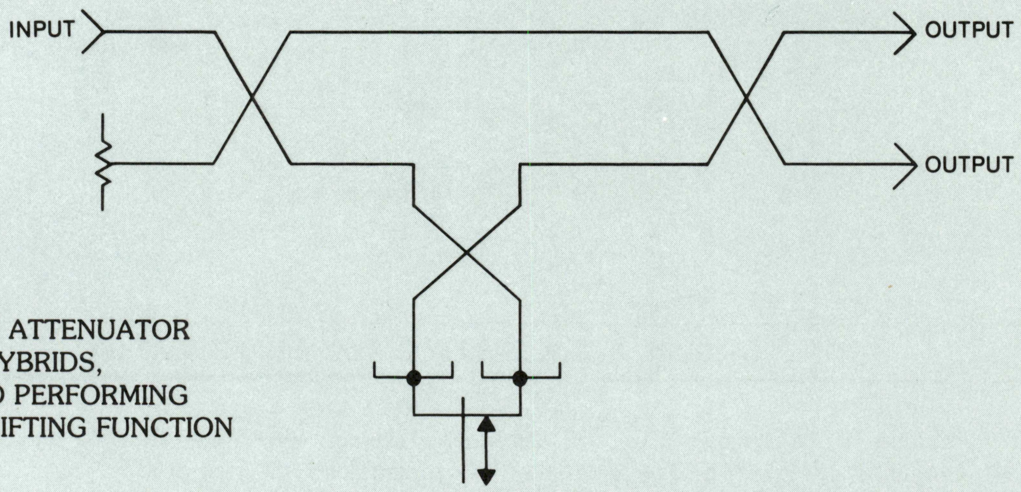
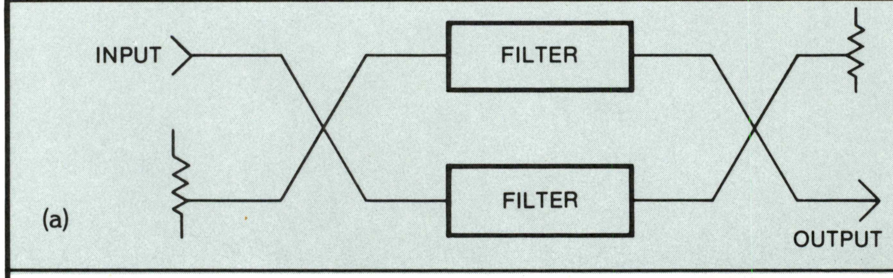


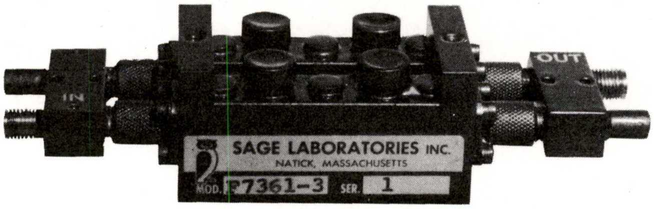
FIGURE 11
A VARIABLE ATTENUATOR
UTILIZING HYBRIDS,
ONE HYBRID PERFORMING
A PHASE SHIFTING FUNCTION

A diplexer with matched filters connected between the hybrids is shown in Figure 12. Sage Model F7361-3 diplexer (shown in Figure 12b), which uses two identical bandpass filters, illustrates the application. The diplexer is a narrowband bandpass filter. Unlike most bandpass filters, however, it terminates out-of-band signals into an internal load rather than reflecting them back to the input. Over the 2.97 — 3.13 GHz passband, the insertion loss is less than 0.9 dB; at 2.8 GHz and at 3.3 GHz, the insertion loss is greater than 20 dB. At 2 GHz and 4 GHz (the hybrid band edges), the insertion loss is greater than 40 dB. The input VSWR is less than 1.5:1 over the full 2 — 4 GHz octave band. An extension of this diplexer idea is to parallel several of these diplexers to perform multiplexing. This can be accomplished by terminating the out-of-band signals in another diplexer, etc. instead of in an internal load.



(a)

FIGURE 12
ZERO RETURN LOSS
DIPLEXER-FILTER ASSY.



(b)

APPLICATION NOTES - COUPLERS & HYBRIDS (Continued)

The most common application for a quadrature hybrid is in a balanced mixer. Figure 13 shows that a balanced mixer consists of a hybrid and two diode detectors.

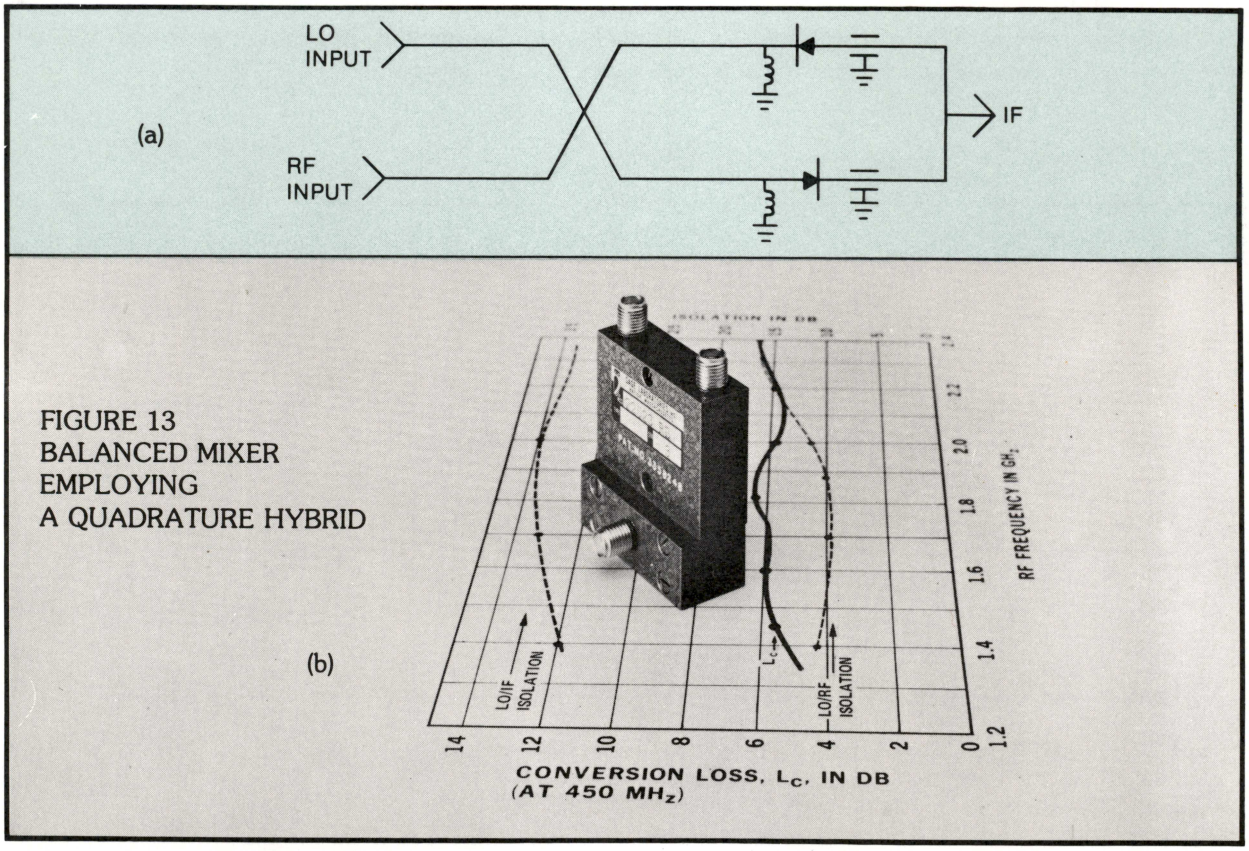

(a)
LO INPUT
RF INPUT
IF
(b)
ISOLATION IN DB
RF FREQUENCY IN GHz
1.2
1.4
1.6
1.8
2.0
2.2
2.4
14
12
10
8
6
4
2
0
LO/IF ISOLATION
L_C
LO/RF ISOLATION
CONVERSION LOSS, L_C, IN DB
(AT 450 MHz)

FIGURE 13
BALANCED MIXER
EMPLOYING
A QUADRATURE HYBRID

An important characteristic of this type of mixer is that it provides L.O. AM Noise suppression of from 20 dB to 40 dB, depending on many factors, such as diode conversion loss and noise temperature, power split, and R.F. phase through the hybrid.

Without this suppression the noise from the L.O. source would be the limiting factor in the overall system noise figure in most radars.

In this balanced mixer, if the hybrid and diodes are matched, all the R.F. and L.O. power is absorbed in the diodes, resulting in low conversion loss. Also, less L.O. power is required than in a single diode mixer.

PHASE QUADRATURE ACCURACY

The quadrature (90 degree) phase relationship between the coupled and main outputs of a symmetric TEM hybrid is often used to advantage. Phase quadrature accuracy can be estimated from a single measurement of isolation. Figure 14 gives an approximate value for the departure of phase from perfect quadrature, as a function of isolation.* The curves assume that there is no differential phase-shift between the coupled segment of transmission line and the output ports. If there is an unequal path-length to a particular output, the phase will have an additional error. In general, however, path-length differences can be compensated for by transmission line lengths in the system.

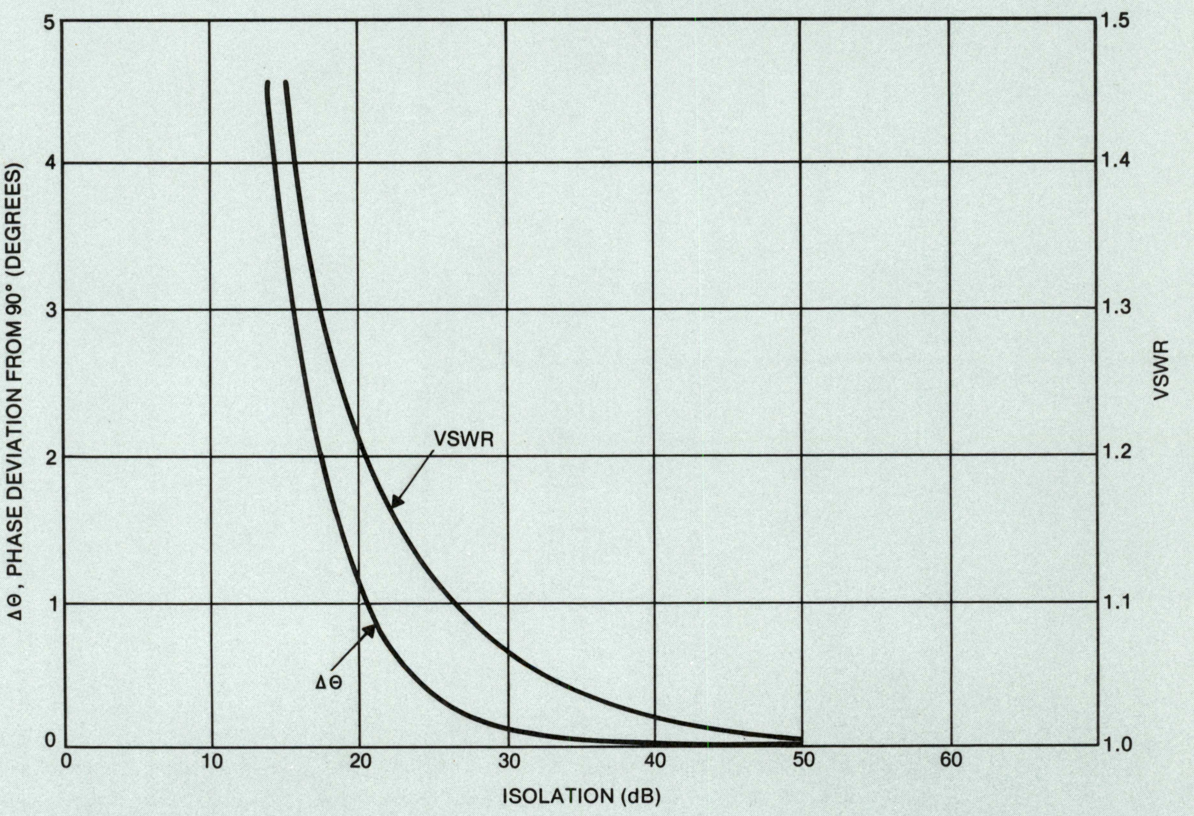


FIGURE 14
THEORETICAL PHASE DEVIATION AND VSWR
OF AN IMPERFECT 3 dB SYMMETRICAL COUPLER

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*Levy, R. -"Directional Couplers," *Advances in Microwaves*, Vol. I, p. 123–124, Academic Press, 1966

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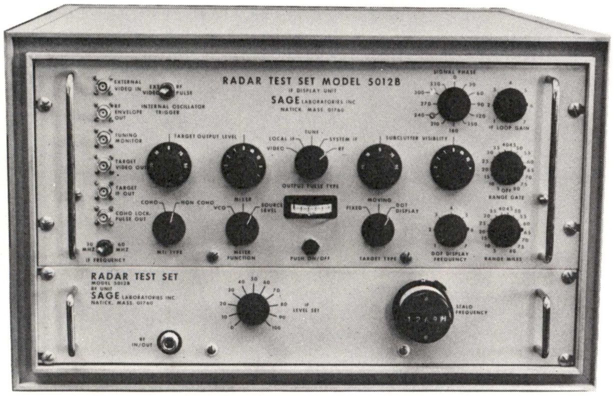
MICROWAVE RADAR COMMUNICATIONS TEST EQUIPMENT

Synchronizers
MTI Radar Test Equipment

sage LABORATORIES, INC.
MODEL 261 SYNCHRONIZER
ON
ON
SIGNAL
LOCKED LOOP
PHASE
FINE TUNE
LAG
HF GAIN
MIXER IF/LO
POWER
20 MHz SIDE TONE
GAIN
CLOSED
STEP TUNE
7
COARSE TUNE
NULL

MODEL 261 COHERENT SYNCHRONIZER/STABILIZER

- converts microwave sweepers into STALOS
- 1 part in 10^8/sec stability
- no crystal changes—no "settling" drift
- hole-free coverage from 1-40 GHz ... semi-automatic search for lock-point


RADAR TEST SET MODEL 5012B
SAGE
RADAR TEST SET
STALO FREQUENCY

MODEL 5012B MTI RADAR SIMULATOR & TEST SET

- evaluates radar at RF, IF & video levels
- targets simulated: fixed, moving-on-fixed, or one then the other
- vastly improves tests

STABILITY TESTER
MODEL 5024
FREQUENCY DEVIATION
FREQUENCY DRIFT KHZ
sage

MODEL 5024 STABILITY TESTER

- accurately measures residual FM, disturbance frequency, & frequency drift in oscillators from 30 MHz to Ku-band
- direct readout of peak frequency deviation to 5% accuracy
- provides for simultaneous observation of disturbance causing residual FM
- simultaneous readout of frequency drift—simple, positive tuning

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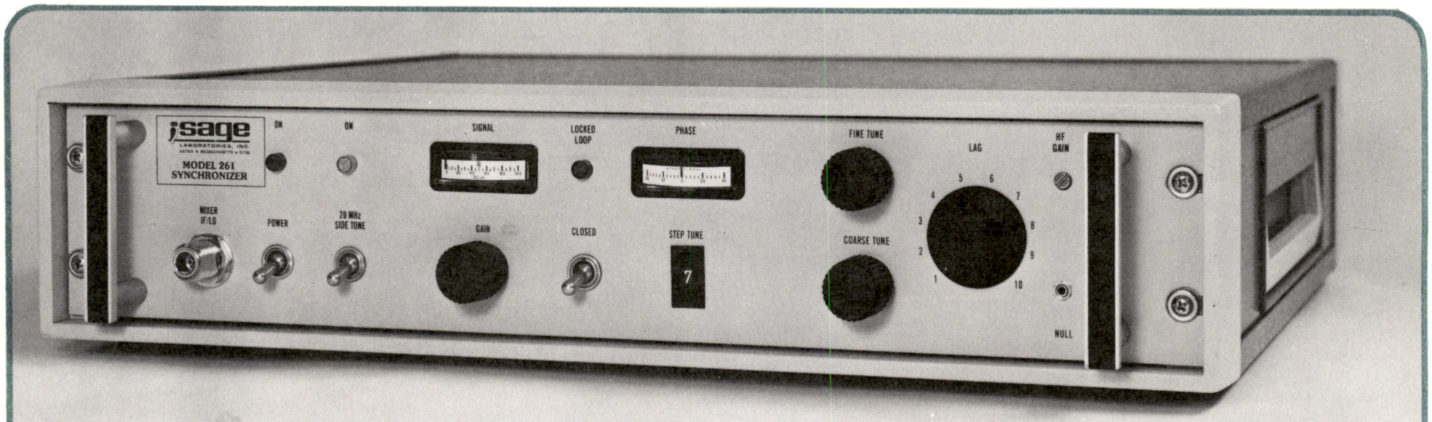
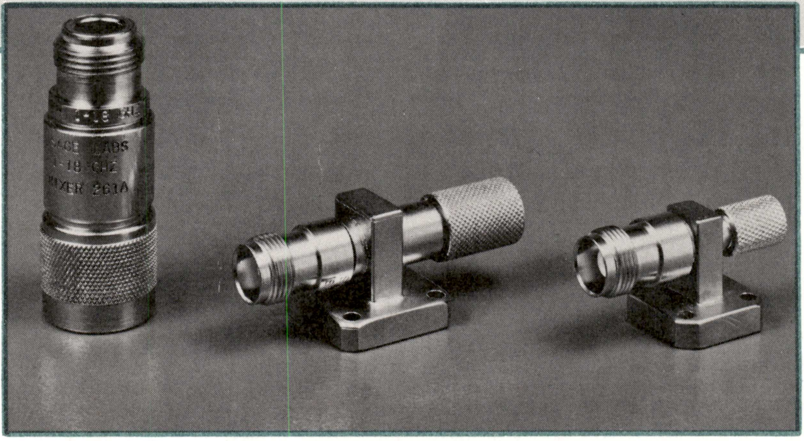
MODEL 261
COHERENT MICROWAVE SYNCHRONIZER/STABILIZER


sage
MODEL 261
SYNCHRONIZER
ON
ON
SIGNAL
LOCKED LOOP
PHASE
FINE TUNE
LAG
HF GAIN
MIXER IF/LO
POWER
20 MHz SIDE TONE
GAIN
CLOSED
STEP TUNE
7
COARSE TUNE
NULL

BASIC 261 MICROWAVE SYNCHRONIZER


SAGE LABS
MIXER 261A

FEATURES

- broadband, solid state
- 1 part in 10^8/sec stability
- derives all frequencies from single built-in oven-controlled quartz crystal oscillator (avoids "settling down" drift normally associated with changing crystals)
- 3 plug in mixers provide hole-free coverage from 1-40 GHz
- built-in digital synthesizer (approx. 100 MHz output)
- semi-automatic search for lock-point ... monitor output permits computation of exact locked frequency
- can be locked to an external standard or synthesizer for primary standard stability (Sage Model 261-6000 interface available)
- Model 261 converts almost any microwave sweeper, BWO, or reflex Klystron into a STALO for use in testing, for LO use in a temporary system, or for use as a source for molecular-resonance testing, etc.
- Accessory allows lock to standard frequency or synthesizer near 1, 2, 5 or 10 MHz for the ultimate in long-time stability
- Frequency monitoring jack allows the use of a 10-MHz counter at one-tenth of synthesizer output frequency
- remote control capability

MODEL 261 COHERENT MICROWAVE SYNCHRONIZER/STABILIZER

(Continued)

DESCRIPTION

Our 261 Microwave Oscillator Synchronizer/Stabilizer will convert any microwave sweeper into a STALO. It provides an economical and versatile means for phase locking a voltage-tunable microwave source to a frequency which is derived from a tunable crystal reference. Model 261 will impart crystal-oscillator stability to klystrons, BWOs, VTMs, and solid state voltage-tunable microwave sources.

APPLICATIONS EXAMPLES—Model 261 will lock a sweeper to a single frequency (CW) for use in testing where, for example, a narrow band detector such as a spectrum analyzer is being used. It will also lock a good klystron or YIG-tuned oscillator to a fixed frequency for use as a local oscillator in a temporary system, or as a source for molecular reasonance testing, etc. Model 261 will lock an oscillator anywhere from 1 to 40 GHz with at least one combination of the frequency controls. It will also lock to certain frequencies in the 150-1000 MHz range.

The key feature of the 261 is the fact that it derives all frequencies from a single built-in oven controlled quartz crystal oscillator. *As a result, there is none of the "settling down" drift normally associated with the changing of crystals.* The combination of this voltage-tuned crystal oscillator (VCXO) and a built-in digital synthesizer,* used in conjunction with the various 261 mixers, provides continuous coverage from 1-40 GHz. For the ultimate in average frequency stability, provision is made for locking the 261 VCXO to an external synthesizer or standard tuned near 1, 2, 5 or 10 MHz. A monitor output near 10 MHz enables you to count the fundamental 261 synthesizer frequency, and to compute the exact locked frequency. The locked oscillator's (VCXO) average frequency is exactly related to the monitoring output frequency (near 10 MHz). The locked oscillator's sideband noise at ± 1 MHz from the oscillator carrier is not affected by the phase-locking, because the correction does not occur with sufficient speed.

Other Features. Two outputs permit you to connect the 261 to an ungrounded element such as a klystron repeller (not more than 3000 volts from ground) or to a grounded FM input jack such as the phase-lock input provided on many sweepers. The 261 mixers can be located locally or remotely, and they connect to the 261 by means of a single coaxial cable. A rear panel jack is provided for remote control of the master oscillator frequency. Tuning of the master oscillator is simplified by a built-in sweep circuit, which provides a single sweep of the crystal oscillator each time the STEP TUNE button is pushed. If a lock point is passed, the signal strength meter deflects.

---

*The comb frequency output of the synthesizer is approximately 100 MHz.

MODEL 261 COHERENT MICROWAVE SYNCHRONIZER/STABILIZER
(Continued)

SPECIFICATIONS

FREQUENCY COVERAGE (Using external interchangeable mixers)		
1-18 GHz	261A mixer	standard
18-26.5 GHz	261B mixer	optional
26.5-40 GHz	261C mixer	optional
RF INPUT		−30 dBm to 0 dBm
FREQUENCY STABILITY		
Short Term		One part in 10^8 per second
Long Term		One part in 10^7 per day*
INTERNAL REFERENCE		Tunable 5 MHz Crystal Oscillator
EXTERNAL REFERENCE		5 MHz ±0.1%*
LOCK-RANGE	Isolated Output	±30 Volts at 40 mA average
	Ground reference output:	±2 or ±12 Volts at 10 mA
MODULATION SENSITIVITY		10 positions, switch-selectable
HIGH VOLTAGE ISOLATION		3000 VDC (high output)
POWER INPUT		115 Volts, 50-133 Hz at 80 VA 230 Volts, 50-133 Hz at 80 VA
CONSTRUCTION		solid state rack-mountable unit supplied in a metal cabinet
MONITORING OUTPUT		100 MHz - Comb Generator frequency divided by 10 (10 MHz at 0.5 Volts RMS)
REMOTE CONTROL		remote control of frequency is provided for
DIMENSIONS		
Installed in cabinet		20" x 4.62" x 18" (50 x 12 x 46 cm)
Less cabinet for rackmount		19" x 3.50" x 16" (48 x 9 x 40 cm)
WEIGHT		
Installed in cabinet		34 lb (16 Kg)
Less cabinet for rackmount		18 lb (8 Kg)

*Jacks permit phase-locking the 261 internal 5 MHz crystal oscillator to a synthesizer or to an external frequency standard, or substituting an external TTL input. The comb oscillator will follow over a range of approximately ±1%. Model 261-6000 optional accessory is available to interface with a 1, 2, 5, or 10 MHz reference frequency input.

OPTIONS

Mixers ... As noted in the table above, the 261B and 261C mixers are extra cost options. They are shown on the lead-off page for 261.

Model 261-6000 External Reference Interface is an optional module which mounts on the 261 rear panel and enables you to phase-lock the 261 to an external reference without degrading either instrument. Model 261-6000 ensures that nothing will be fed back into your synthesizer, and it isolates the 261 from any noise which may be present at the synthesizer output. Model 261-6000 accepts external sine or square inputs with levels of 0.1 volt (-7 dBm) minimum, 0 dBm nominal, at 1, 2, 5 or 10 MHz.

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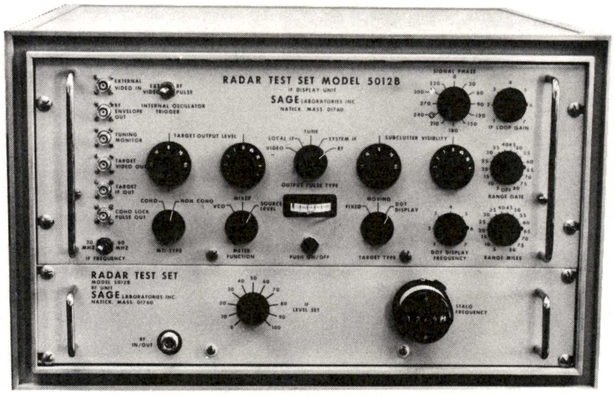
MODEL 5012B MTI RADAR SIMULATOR & TEST SET

FEATURES

- measures Sub-Clutter Visibility (SCV) of MTI radar systems
- evaluates systems at RF, IF, and video levels
- connects directly to radar's directional coupler & injects simulated fixed & moving targets
- both fixed & moving targets can be time-shared displayed, allowing for a vivid presentation that vastly improves the measurement technique


RADAR TEST SET MODEL 5012B
IF DISPLAY UNIT
SAGE LABORATORIES INC
NATICK, MASS. 01760
EXTERNAL VIDEO IN
RF ENVELOPE OUT
INTERNAL OSCILLATOR TRIGGER
TUNING MONITOR
TARGET VIDEO OUT
TARGET IF OUT
COHO LOCK PULSE OUT
IF FREQUENCY
TARGET OUTPUT LEVEL
LOCAL IF
TUNE
SYSTEM IF
VIDEO
RF
OUTPUT PULSE TYPE
SUBCLUTTER VISIBILITY
SIGNAL PHASE
IF LOOP GAIN
RANGE GATE
COHO
NON COHO
MTI TYPE
VCO
MIXER
SOURCE LEVEL
METER FUNCTION
PUSH ON/OFF
FIXED
MOVING
DOT DISPLAY
TARGET TYPE
DOT DISPLAY FREQUENCY
RANGE MILES
RADAR TEST SET
MODEL 5012B
RF UNIT
SAGE LABORATORIES INC.
NATICK, MASS. 01760
IF LEVEL SET
STALO FREQUENCY
RF IN/OUT

SPECIFICATIONS

RF INPUT CHARACTERISTICS	
Frequency	1180-1350 MHz standard (others available on request)
Maximum Power	1000 watts peak 1 watt average (50 ohms)
Pulse Repetition Frequency	100-4500 Hz
Pulse Width	1 to 10 microseconds
TARGET ECHOES	
Range	5-80 nautical miles in 5-mile increments
Type	fixed, moving on fixed, or dot display
Fixed/Moving Target Ratio	0-40 dB
IF	30 MHz or 60 MHz (91 ohms)
RF	coherent with input frequency (50 ohms)
Video Envelope Output	
COHO LOCK PULSE OUTPUT	30 MHz or 60 MHz (91 ohms)
INTERNAL PULSED COHO OSCILLATOR	2.5 microsecond pulse width
INTERNAL PULSED OSCILLATOR TRIGGERING	
RF pulse or	
External video trigger	(5 volts min./100 volts max./pos.or neg.)
RF ENVELOPE OUTPUT	50 millivolts nominal
TUNING MONITOR OUTPUT	2 volts nominal
INTERNAL IF:	42 MHz

MODEL 5012B MTI RADAR SIMULATOR & TEST SET (Continued)

MOVING TARGETS GENERATED BY MODEL 5012B - COHO SYSTEM TEST

TEST MODE	30 OR 60 MHz COHO LOCK PULSE SOURCE	PULSE TRIGGER	TARGET OUTPUT(S) (5-80 NAUT. MI.)	MOVING TARGET MODULATION
RF	Transmitted RF	N/A	RF	Phase
System IF	Transmitted RF	N/A	IF (30 or 60 MHz)*	Phase
Local IF	5012B COHO	Radar SYN	IF (30 or 60 MHz)*	Phase
Video	5012B COHO	Transmitted RF or SYN gen.	Video	Amplitude

*or two other IF's as required

MOVING TARGETS GENERATED BY MODEL 5012B - NON-COHO SYSTEM TEST
(All moving targets amplitude-modulated: all targets at $\sim$ 5 naut. mi.)

TEST MODE	OVERLAPPED TARGETS?	PULSE TRIGGER	TARGET OUTPUT
RF	Yes	N/A	RF
System IF	Yes	N/A	IF (30 or 60 MHz)
Local IF	No	Radar SYN	IF
Video	No	Transmitted RF or SYN gen.	Video

5012B TUNING AIDS: (1) Video envelope of transmitted pulse, (2) CW 30 or 60 MHz output, (3) Beat note between 5012B COHO and 5012B IF pulse derived from transmitted RF pulse

SUMMARY

Model 5012B generates fixed and moving targets to permit quantitative tests of the subclutter visibility ratio of an MTI radar. It provides targets at RF, IF, and video frequencies, in order to isolate problems within the radar system. Model 5012B can be used to test both coherent (COHO) and noncoherent MTI radars.

The 5012 RF Heads are custom designed for the customer's particular band of interest. The RF Head includes a STALO, a level set attenuator, up and down converters to the 42 MHz IF, and a Transmitted/Received Pulse duplexer. Typical of units previously supplied is an L-Band unit using a continuously (manually) tuned cavity-stabilized transistor oscillator. A typical X-Band unit used a varactor-tuned Gunn oscillator, phase-locked to a VHF crystal oscillator at discrete points across the 8.5-9.6 GHz band.

Model 5012B is packaged primarily for in-plant use; however, it *is* transportable. The 5012B IF section weighs approximately 28 pounds. The 5012B RF unit for L-Band, for example, weighs about 12 pounds. The two units fit into an instrument rack cabinet with a panel height of 10½ inches and a total weight of approximately 60 pounds. Primary power is 115/230 volts, 50 to 400 Hz.

OTHER SAGE INSTRUMENTS USEFUL IN COHERENT MTI WORK

(1) Model 5024 Microwave Stability Tester - used for quantitative measurements of STALO FM deviation (2) Model 261 Coherent Microwave Synchronizer/Stabilizer - used to stabilize an available voltage-tunable source to provide a versatile STALO for test purposes (3) Stable Oscillators (4) Model 5015 Pulse Jitter Tester - used to measure pulse width jitter, relative jitter, and pulse repetition rate (PRF) jitter.

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MODEL 5024 MICROWAVE STABILITY TESTER

FEATURES

- accurately measures residual FM, disturbance frequency, and frequency drift in oscillators ranging from 30 MHz to Ku-band
- evaluates STALO-type oscillators, synthesizers, etc. via simple technique
- provides direct read-out of peak frequency deviation to 5% accuracy
- provides for simultaneous observation of disturbance frequency causing residual FM
- provides simultaneous read-out of frequency drift on zero-center meter
- simple, positive tuning

STABILITY TESTER
MODEL 5024
FREQUENCY DEVIATION HZ
FREQUENCY DRIFT KHZ
CRYSTAL CURRENT
SIGNAL LEVEL
POWER
sage

FUNCTIONAL DESCRIPTION

Model 5024 is used to evaluate STALO-type oscillators, synthesizers, etc. by means of a fairly simple measuring technique. The stability of the STALO under test is measured for slow variations (on a "drift" meter) and for FM sidebands in the 10-20,000 Hz region, by tuning the STALO in on an FM receiver. The receiver LO is supplied by a variable-frequency crystal oscillator which generates many harmonics in the microwave range. The STALO is beat with one of these harmonics, and converted down to an IF. Following the IF amplifier, there is a detector for measurement of the FM average frequency and the RMS sideband noise. A 5-position switch permits selecting the upper limit of the FM sideband noise (from 15-150 Hz in the lowest position to 15-20,000 Hz at the widest setting).

MODEL 5024 MICROWAVE STABILITY TESTER (Continued)

SPECIFICATIONS

5024 MIXERS
RF plug-ins available, 1–18 GHz

MINIMUM MEASURABLE PEAK DEVIATION (1 through 15 GHz)

15-150 Hz band	2 parts in 10^9
15-500 Hz band	2.5 parts in 10^9
15 Hz to 1.5 KHz band	3 parts in 10^9
15 Hz to 10 KHz band	8 parts in 10^9
15 Hz to 20 KHz band	1.5 parts in 10^8

PEAK DEVIATION METER RANGES (Accuracy better than 5% of full scale)
0-10 Hz, 0-30 Hz, 0-100 Hz, 0-300 Hz, 0-1000 Hz, 0-3000 Hz, 0-10,000 Hz, 0-30,000 Hz

DRIFT METER RANGES .... ±5 KHz & ±50 KHz about center frequency

DISTURBANCE FREQUENCY FILTER RANGES (@ 3 dB)
15-150 Hz, 15-500 Hz, 15-1500 Hz, 15-10,000 Hz, 15-20,000 Hz

SIGNAL INPUTS (& CONNECTORS) .... MIXER LO/IF (Type N)

SIGNAL OUTPUTS (& CONNECTORS) .... Disturbance Frequency Waveform (BNC) and 2nd IF Waveform (BNC) on front panel

TUNING CONTROLS .... Step, Coarse, and Fine Tuning

DIMENSIONS & WEIGHT...(EXISTING DESIGN).......... panel 12-1/4"H × 19"W for standard RETMA rack, 16-7/8"D, weight 65 lbs. Cabinet available at slight additional cost.
NEW DESIGN WILL REDUCE SIZE & WEIGHT BY APPROXIMATELY 50%.

POWER REQUIREMENTS .... 105-125 VAC, 50-60 Hz, @ 450 Watts

A companion instrument which may be of interest for routine radar tests is our 5015 Pulse Jitter Tester, which pulses an LC oscillator coherently with a trigger pulse from the radar, and counts cycles until the next pulse. A phase (time) detector measures the interval, and compares the variation from one interpulse interval to another.

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VIDEO DETECTORS AND DIODE HOLDERS

CONTENTS OF THIS SECTION

PAGE

A Guide to Selection **219**
Custom Engineering Capabilities **221**
Standard Products **223**
Application Notes **228**

A GUIDE TO SELECTION

Sage Laboratories' standard line of video detectors and diode holders offers you complete coverage through 47 GHz for many applications in the area of RF detection. The miniature detector line is primarily intended for high sensitivity system applications. The diode holders (coaxial and waveguide) have been designed with instrument applications in mind. In actual practice, the two product lines can be used for either application.

All Sage video detectors are factory-checked to ensure rated performance. All models use miniature field-replaceable diodes. Our diode holders are versatile; they provide satisfactory performance in such widely varied applications as video detection, power monitoring, and general laboratory use.

Both product lines are value-engineered. All diodes supplied with the units are quickly available from the diode manufacturers.

VIDEO DETECTORS

Our standard video detectors were developed to satisfy customer demands for higher sensitivity and reliability. All models have unique design features which result in premium performance. These design features include the following.

- plug-in DC return* modules which ensure a high degree of reproducibility in performance characteristics
- elimination of fragile finger contacts in the diode holders
- precision spring-loaded RF contacts which eliminate diode mechanical tolerance problems and ensure positive RF contact

Except for the D25S106, all models are miniature units using passivated stainless steel SMA connectors intended primarily for miniature packaging applications. Model D25S106, offered to satisfy your retrofit requirements, incorporates all basic design features listed above, and can be adapted quickly to any desired RF input connector. The input connector is actually a TNC female adaptor which, for our standard D25S106, is fitted with a type N male connector. It is a simple matter to disassemble this and screw a different TNC adaptor into place. This enables you to take advantage of recent improvements in video detector design with little or no mechanical change in older systems.

*See Application Notes for explanation of DC returns.

BROADBAND DIODE HOLDERS

Our coaxial diode holders include models operating through 15 GHz. Our waveguide diode holders cover the range through 47 GHz. Many connector and diode options are available in the coaxial units. The waveguide models use appropriate frequency band flange configurations and BNC video output connectors. All designs are broadband. Although not specifically characterized for high sensitivity video detection applications, these units can be used for this purpose. Close tracking matched pairs can also be provided on special request. (Please see next section, CUSTOM ENGINEERING CAPABILITIES.)

All coaxial diode holders can be provided with DC returns optimized for selected RF bands. These are ordered by adding the appropriate suffix letter to the basic model number, as explained on the standard product page.

All Sage video detectors and diode holders are ruggedly constructed and designed for MIL-E-5400 II operation.

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CUSTOM ENGINEERING CAPABILITIES IN VIDEO DETECTORS AND DIODE HOLDERS

MATCHED VIDEO DETECTOR CONSIDERATIONS

All Sage video detectors are suitable for matched performance applications. It has become important in many system applications for video detectors to track each other in frequency and power output characteristics. Such matched sets can involve pairs, quads, groups of ten, and even larger sets. Sage Laboratories has supplied many such matched sets on special orders. In general, the narrower the RF bandwidth, the better the tracking capability.

A key factor in any tracking consideration is the reproducibility of diode characteristics. Schottky and back-diodes offer the best reproducibility, and represent a considerable improvement over what was previously available with point-contact diodes. This has been made possible through the ability to relate low frequency measurements to the relative RF performance of Schottky and back-diodes.

With our octave-band video detectors, the tracking performance which can be provided is typically ±0.5 dB up to 0 dBm for Schottky diode detectors, and ±0.5 dB up to −13 dBm for detectors using back-diodes. An offset of ±1 dB is usually required, and can be compensated for in your system by a simple DC adjustment.

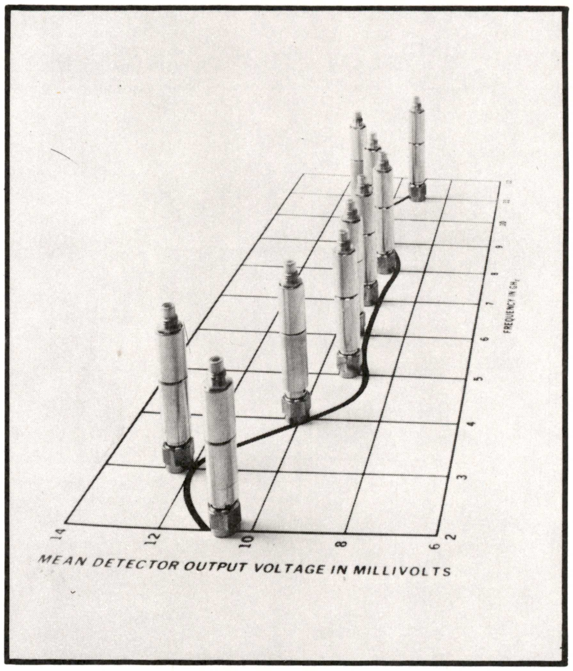


FIGURE 1 - A TYPICAL MATCHED SET OF VIDEO DETECTORS

MATCHED DIODE HOLDER CONSIDERATIONS

Our standard coaxial and waveguide diode holders also can be modified for close-tracking matched pairs for applications such as sweepers and tracking receivers.

CUSTOM ENGINEERING CAPABILITIES IN VIDEO DETECTORS & DIODE HOLDERS (Continued)

OPTIMIZATION OF STANDARD DETECTORS & DIODE HOLDERS FOR YOUR REQUIREMENTS

On special order, Sage Laboratories can modify its standard video detectors and diode holders for peak performance within your special bands of interest. Figure 2 shows the performance characteristics of one such unit. Note the combination of excellent VSWR and sensitivity characteristics. We invite your engineering inquiries regarding such modifications.

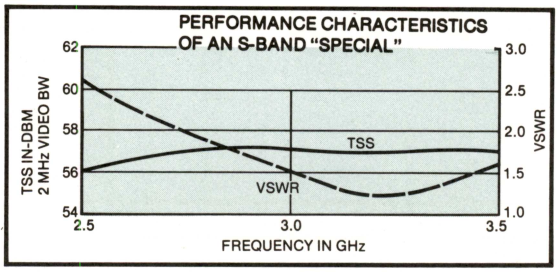
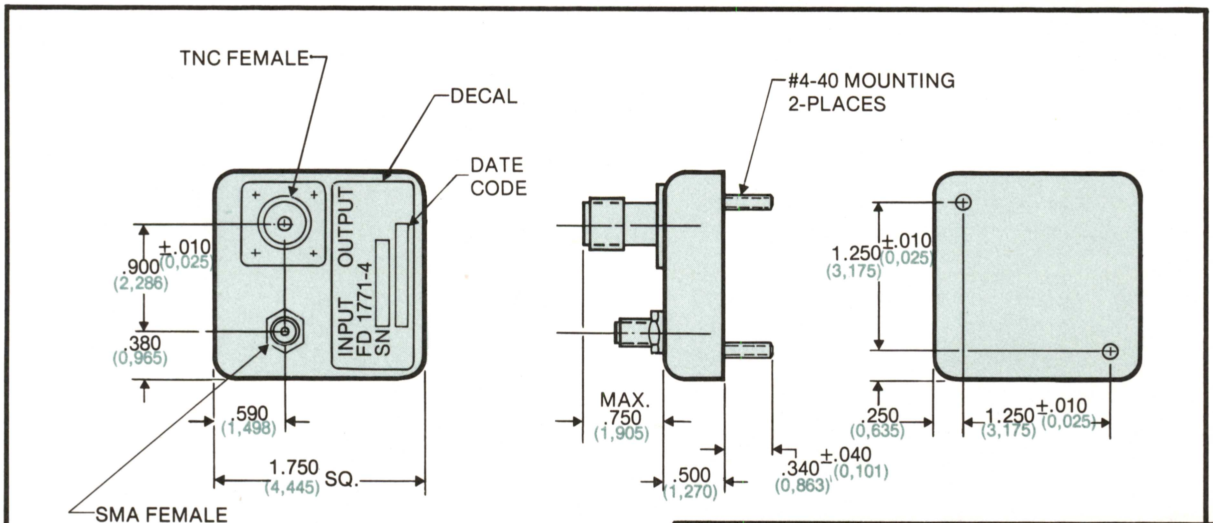


FIGURE 2 - PERFORMANCE CHARACTERISTICS OF A SAGE VIDEO DETECTOR OPTIMIZED FOR A CUSTOMER'S S-BAND SYSTEM.

DEVELOPMENT OF CUSTOM-ENGINEERED VIDEO DETECTORS & DIODE HOLDERS


TNC FEMALE
DECAL
DATE CODE
OUTPUT
INPUT
FD 1771-4
SN
±.010
.900 (0,025)
(2,286)
.380
(0,965)
.590
(1,498)
1.750 SQ.
(4,445)
SMA FEMALE
#4-40 MOUNTING
2-PLACES
MAX.
.750
(1,905)
.500
(1,270)
±.040
.340 (0,101)
(0,863)
±.010
1.250 (0,025)
(3,175)
.250
(0,635)
1.250 ±.010
(3,175) (0,025)

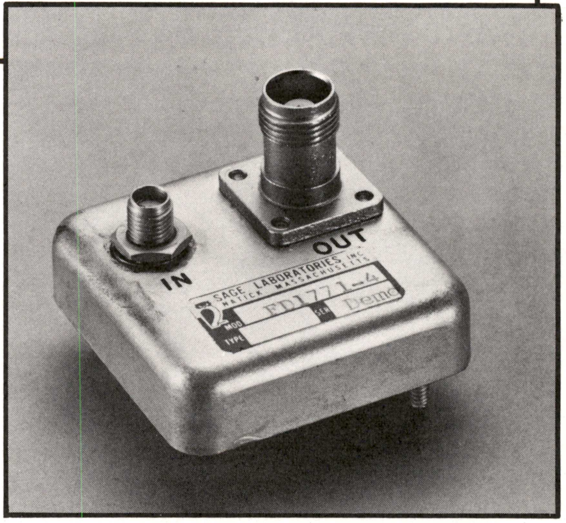

OUT
IN
SAGE LABORATORIES, INC.
NATICK, MASSACHUSETTS
FD1771-4

FIGURE 3 - TACAN VIDEO DETECTOR

Developed for a TACAN Test Set to provide absolute power reading, this detector provides fast square law pulse response from 0 to +18 dBm input with low VSWR (1.2:1 max.) and flat frequency response from 1025 to 1150 MHz. We invite your engineering inquiries regarding video detectors or diode holders which you may wish to have custom-engineered for your system requirements.

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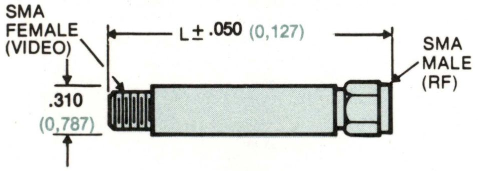
MINIATURE COAXIAL OCTAVE BAND & MULTI-OCTAVE BAND VIDEO DETECTORS

FEATURES

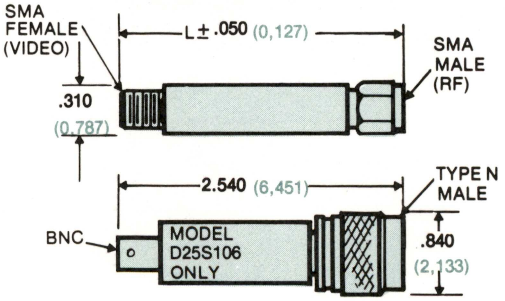
- high sensitivity
- Schottky & back-diode versions
- plug-in DC return modules
- fingerless diode contacts
- interchangeable RF connector (Model D25S106 only)
- tracking matched sets available on special order
- designed for MIL-E-5400 Class II

MECHANICAL DATA

OCTAVE BAND HIGH SENSITIVITY VIDEO DETECTORS


SMA
FEMALE
(VIDEO)
L ± .050 (0,127)
SMA
MALE
(RF)
.310
(0,787)

MULTI OCTAVE BAND HIGH SENSITIVITY VIDEO DETECTORS


SMA
FEMALE
(VIDEO)
L ± .050 (0,127)
SMA
MALE
(RF)
.310
(0,787)
2.540 (6,451)
TYPE N
MALE
BNC
MODEL
D25S106
ONLY
.840
(2,133)

MATERIALS & FINISHES

Model D25S106 body fabricated in brass, silver-plated & rhodium-flashed
Connectors passivated stainless steel or gold-plated beryllium copper
Contacts beryllium copper, gold-plated
All materials to Govt. specs

Other models fabricated from beryllium copper gold-plated
Connectors passivated stainless steel or gold-plated beryllium copper
Contacts beryllium copper, gold-plated
All materials to Govt. specs

MINIATURE COAXIAL OCTAVE BAND & MULTI-OCTAVE BAND VIDEO DETECTORS (Continued)

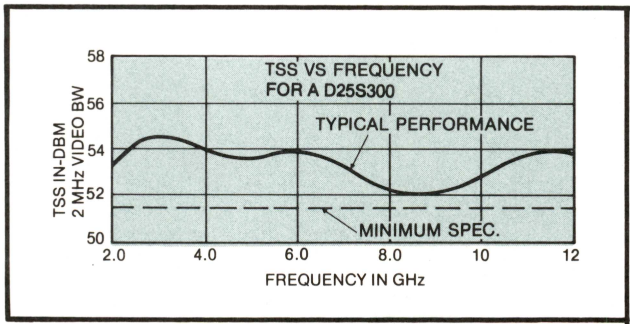
ELECTRICAL SPECIFICATIONS

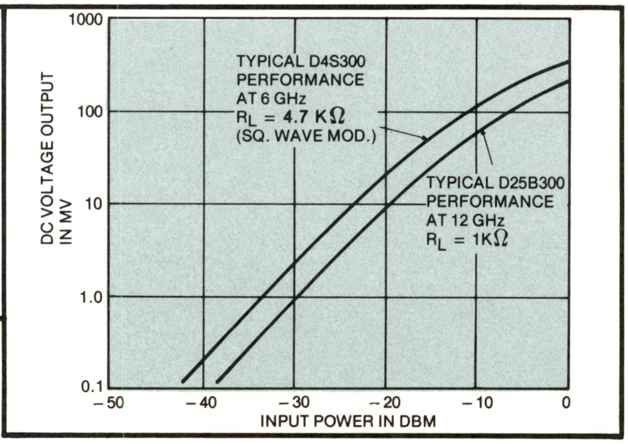
MODEL NO.	FREQUENCY RANGE (GHz)	DIODE TYPE	MINIMUM TSS* (dBm) WITH 2 MHz VIDEO BANDWIDTH	LENGTH (L) in.	cm
D25S106	2-12	D5754	−51.5	2.54	
D25B300	2-12	KMC GBD 250A**	−49	2.06	
D25S300	2-12	D5754	−51.5	2.06	
D2S300	1-2	D5754	−53	2.40	
D3S300	2-4	D5754	−55	2.40	
D4S300	4-8	D5754	−55	2.06	
D5S300	8-12	D5754	−53	2.06	
D6S300	12-18	MA 40029	−51	2.06	

*All Schottky diode units require 25-100 micro-amperes bias

**D25B300 is a back-diode unit. All others are Schottky. Normal output is negative for Schottky diode units. The output polarity of Schottky diode units can be reversed by turning the diodes around. Output polarity of the D25B300 back-diode unit is positive; it cannot be reversed.

Model D25S106 is available in many different RF connector configurations. All other models use SMA male for RF and SMA female for video.





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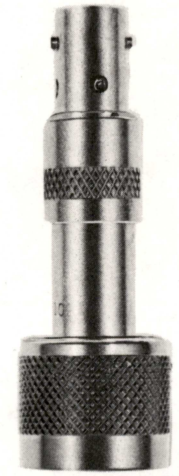
BROADBAND COAXIAL DIODE HOLDERS

FEATURES

- 17 models covering 10-15,000 MHz & accomodating 5 popular diode types
- all models suitable for mixer or video detector applications
- output sections interchangeable within given series
- diodes and DC returns extra-cost options
- stock models can be modified for special requirements such as close-tracking matched pairs for sweepers & tracking receivers



MATERIALS & FINISHES

Brass shells & center conductors
Beryllium copper contacts

All metals silver-plated & rhodium-flashed
All SAGELINE materials & finishes to Gov't specs

MODEL NO.	INPUT CONNECTOR	OUTPUT CONNECTOR	MAX. DIMENSIONS DIA. in.	cm	LENGTH in.	cm	T.S.S.* WITH DIODE SHOWN
		FOR CARTRIDGE DIODES					1N21E
1021	Type N Male	BNC Female	.843	(2,141)	2.359	(5,992)	−40 dBm
1022	Type N Male	TNC Female	.843	(2,141)	2.437	(6,191)	−40 dBm
1023	Type N Male	50 ohm Microdot	.843	(2,141)	2.125	(5,397)	−40 dBm
1026	Type N Male	Type N Female	.843	(2,141)	2.671	(6,786)	−40 dBm
1262	TNC Male	TNC Female	.593	(1,508)	2.406	(6,111)	−40 dBm
		FOR LARGE COAXIAL DIODES					1N78B
1071	Type N Male	BNC Female	.843	(2,141)	2.562	(6,508)	−40 dBm
1072	Type N Male	TNC Female	.843	(2,141)	2.468	(6,270)	−40 dBm
1073	Type N Male	50 ohm Microdot	.843	(2,141)	1.921	(4,881)	−40 dBm

*Tangential Signal Sensitivity, as measured with specified diodes and 10 MHz video bandwidth

continued

BROADBAND COAXIAL DIODE HOLDERS (Continued)

MODEL NO.	INPUT CONNECTOR	OUTPUT CONNECTOR	MAX. DIMENSIONS				T.S.S.* WITH DIODE SHOWN
			DIA.		LENGTH		
			in.	cm	in.	cm	
		FOR SMALL COAXIAL DIODES					1N53B
1231	Type N Male	BNC Female	.843	(2,141)	2.171	(5,516)	−40 dBm
		FOR TRIPOLAR DIODES					1N358A
1011	Type N Male	BNC Female	.843	(2,141)	2.171	(5,516)	−45 dBm
1012	Type N Male	TNC Female	.843	(2,141)	2.250	(5,715)	−45 dBm
1013	Type N Male	50 ohm Microdot	.843	(2,141)	1.968	(5,000)	−45 dBm
1016	Type N Male	Type N Female	.843	(2,141)	2.437	(6,191)	−45 dBm
1332	TNC Male	TNC Female	.625	(1,587)	2.203	(5,595)	−45 dBm
		FOR HIGH TEMPERATURE TRIPOLAR DIODES					1N630
1221	Type N Male	BNC Female	.843	(2,141)	2.171	(5,516)	−40 dBm
1222	Type N Male	TNC Female	.843	(2,141)	2.250	(5,715)	−40 dBm
1352	TNC Male	TNC Female	.593	(1,506)	2.203	(5,595)	−40 dBm

*Tangential Signal Sensitivity, as measured with specified diodes and 10 MHz video bandwidth

HOLDER CLASSFICATION	FREQUENCY RANGE – UNLESS LIMITED BY DC RETURN	TOTAL CAPACITY*	ASSOCIATED DIODES	
Cartridge	10-8,000 MHz Recommended useable to 15,000 MHz	6-7 mmf	1N21 1N23	1N25 1N32
Large Coaxial	10-15,000 MHz	5-10 mmf	1N26 1N31	1N76 1N78
Small Coaxial	10-15,000 MHz	5-10 mmf	1N53	1N446
Tripolar	10-15,000 MHz	7-8 mmf	1N369 1N1132	1N358
High Temperature Tripolar	10-15,000 MHz	7-8 mmf	1N630 1N2127	1N1610

*The output capacity of the Tripolar holder is determined by the diode itself.

DC RETURNS

To specify an internal DC Return add the appropriate suffix for the recommended frequency range listed.

RECOMMENDED FREQUENCY RANGE	SUFFIX LETTER
1,000 – 15,000 MHz	H
400 – 8,000 MHz	I
150 – 4,000 MHz	J
40 – 2,000 MHz	K
10 – 1,000 MHz	L

Note: The addition of an internal DC Return does not increase the size of the diode holder.

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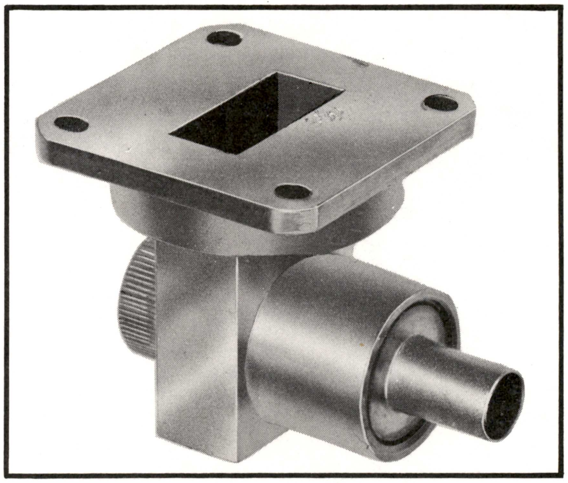
LABORATORIES, INC.
3 HURON DRIVE • NATICK, MASS. 01760
TEL: 617-653-0844 • TWX: 710-346-0390

BROAD BAND WAVE-GUIDE DIODE HOLDERS

FEATURES

- 19 models covering 5.1-47 GHz and accomodating 4 popular diode types
- all models suitable for mixer or video detector applications
- Small Coax, Large Coax, and Tripolar holders recommended for full waveguide band applications
- cartridge holders recommended for narrower-band, higher sensitivity applications
- diodes optional
- female BNC output connectors standard
- Microdot, Solderlug & female TNC connectors optional at no extra cost
- stock models can be modified for special requirements such as "close-tracking matched pairs" for sweepers and tracking receivers



MATERIALS & FINISHES

Fabrication in brass standard
Aluminum optional at no extra cost
Beryllium copper contacts and center conductors

All metals silver-plated and rhodium-flashed
All SAGELINE materials and finishes to Govt. specs

MODEL NUMBER	FREQUENCY RANGE (MHz)	HOLDER CLASSIFICATION	PRIMARY APPLICATION	TOTAL* CAPACITANCE	DIODE (IF SUPPLIED)
1161	5100-5900	Cartridge	Video	2-3 mmf	1N23E
1151		Cartridge	Mixer	2-3 mmf	1N23E
1141	7200-8200	Cartridge	Mixer	2-3 mmf	1N23E
1641	7500-10,000	Tripolar	Vid/Mix	6-7 mmf	1N358A
1031	8200-12,400	Tripolar	Vid/Mix	6-7 mmf	1N358A
1081		Large Coaxial	Vid/Mix	9-11 mmf	1N78B
1121	8500-9600	Cartridge	Video	2-3 mmf	1N23E
1111		Cartridge	Mixer	2-3 mmf	1N23E
1131	9500-10,300	Cartridge	Mixer	2-3 mmf	1N23E
1171	9500-15,600	Tripolar	Vid/Mix	6-7 mmf	1N358A
1531	10,800-15,000	Large Coaxial	Vid/Mix	9-11 mmf	1N78B
1041	12,400-18,000	Tripolar	Vid/Mix	6-7 mmf	1N358A
1091		Large Coaxial	Vid/Mix	9-11 mmf	1N78
1701	14,000-22,000	Tripolar	Vid/Mix	6-7 mmf	1N358A
1051	18,000-26,500	Tripolar	Vid/Mix	6-7 mmf	1N358A
1101		Large Coaxial	Vid/Mix	9-11 mmf	1N26A
1741	22,000-33,000	Small Coaxial	Vid/Mix	9-11 mmf	1N53B
1061	26,500-40,000	Small Coaxial	Vid/Mix	9-11 mmf	1N53B
1751	33,000-47,000	Small Coaxial	Vid/Mix	9-11 mmf	1N53B

*The output capacitance of the Tripolar holder is determined by the diode itself.

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APPLICATION NOTES VIDEO DETECTORS & DIODE HOLDERS

INTRODUCTION

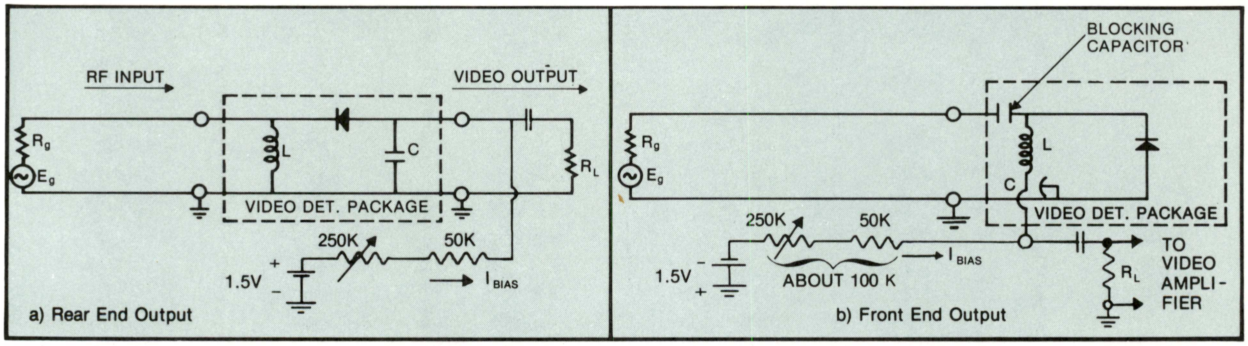
Although many innovations have taken place in high sensitivity receiving systems, video detectors (with their relatively poor sensitivity) remain the most practical choice for many receiver systems and instrumentation applications, because they are simple and inexpensive. The video detector is simple because it can directly detect incident RF energy without the use of auxiliary RF power sources or microwave amplification. It is economical because it involves a single diode and diode-holder.

When you do not require the ultimate in sensitivity, video detectors are probably your best choice. A few typical applications using video detectors are beacon receivers, countermeasures receivers, missile guidance receivers, power monitors, and detection elements for RF leveled systems.

BASIC DETECTOR THEORY

Although not often thought of in this manner, the video detector essentially serves to transform one frequency range to another; viz. RF to video. (See Figure 1a.) Incident power reaches the diode, which is preceded by a high impedance RF coil, L, a choke shunting the transmission line. (This choke is normally referred to as a DC return.) Ideally, all power is absorbed by the diode, and an RF short circuit is provided by the bypass capacitor, C, to ensure this. Through rectification by the diode, a video signal is generated, typically in the range from DC to 10 MHz. This signal is delivered to the video load, R_L, and the previously mentioned RF choke now acts as a short circuit. The bypass capacitor, which appeared as a short circuit to RF, now has little effect because of its high impedance at video frequencies. (Its capacitance is normally in the range of 20 pf.

Of course, all circuit components fall short of ideal performance, resulting in a sensitivity decrease from the ideal amounting to from 1 to 10 dB. Normally, the wider the RF bandwidth, the greater the loss in sensitivity. RF match of the diode is usually the worst offender.



a) Rear End Output

b) Front End Output

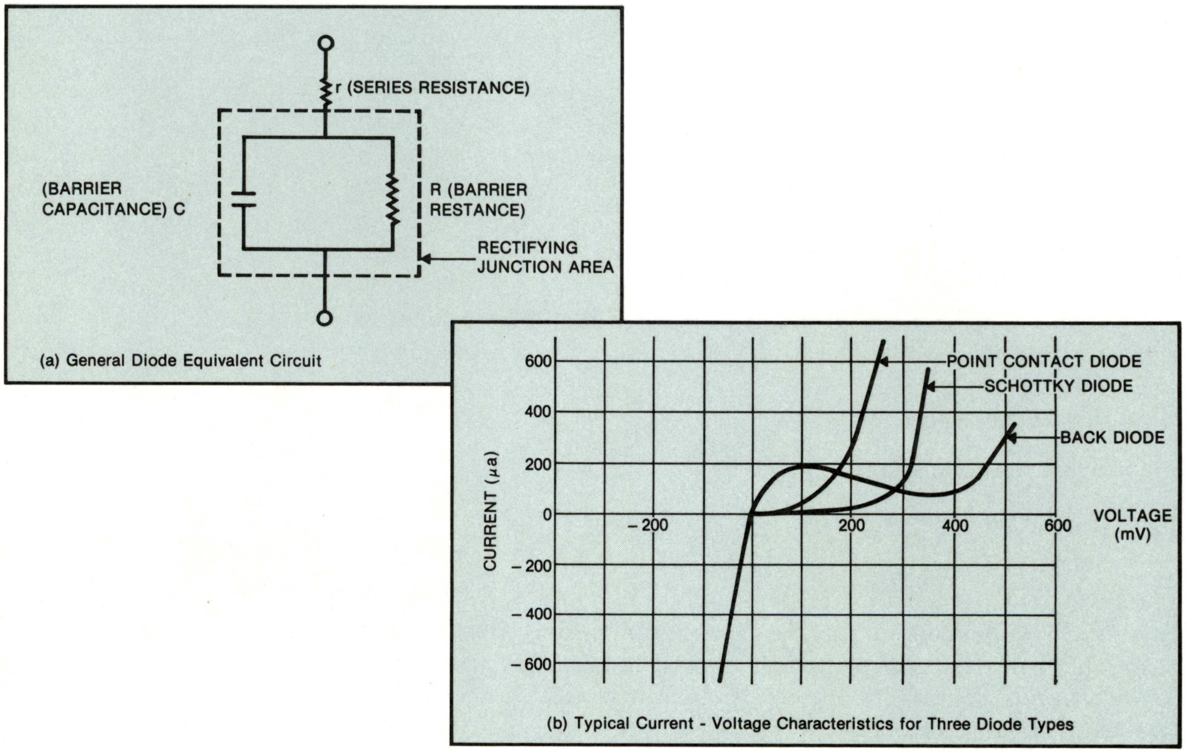
FIGURE 1 BASIC VIDEO DETECTOR SCHEMATICS

APPLICATION NOTES - VIDEO DETECTORS & DIODE HOLDERS (Cont'd)

The video paths are the only difference between the two types of video detector packages shown in Figure 1. The foregoing discussion pertains to both. Your choice between these two basic circuits will usually be determined by mechanical considerations. This is illustrated in a later section of this discussion.

Diode Detection Equations

A basic similarity of all detector diodes is their non-linear current-voltage relationship. Figure 2 shows this characteristic for three diode types, together with their general equivalent circuit.


r (SERIES RESISTANCE)
(BARRIER CAPACITANCE) C
R (BARRIER RESTANCE)
RECTIFYING JUNCTION AREA
600
400
200
0
– 200
– 400
– 600
CURRENT (μa)
– 200
200
400
600
VOLTAGE (mV)
POINT CONTACT DIODE
SCHOTTKY DIODE
BACK DIODE

(a) General Diode Equivalent Circuit

(b) Typical Current - Voltage Characteristics for Three Diode Types

FIGURE 2-GENERAL DIODE EQUIVALENT CIRCUIT AND CURRENT-VOLTAGE RELATIONSHIPS FOR THREE DIODE TYPES

APPLICATION NOTES - VIDEO DETECTORS & DIODE HOLDERS (Cont'd)

A close approximation of the diode current-voltage characteristics shown in Figure 2 can be calculated by use of a Taylor expansion in the vicinity of a bias voltage, V_0, which will cause some quiescent current, I_0, to flow.

$$I_0 + \delta I = f(V_0) + f'(V_0)\delta V + \tfrac{1}{2} f''(V_0)\delta V^2 + \; \ldots\ldots \tag{1}$$

where I and V represent the related incremental current and voltage changes that would result from a small applied RF signal. This expression, when combined with the theoretical current voltage relationship of a diode

$$i = i_0(e^{av} - 1) \tag{2}$$

will result in expressions for both current and voltage sensitivity of a diode. These are shown in equations (3) and (4) respectively.

$$\beta = \frac{i}{p} = \left[\frac{a}{2(1+\frac{r}{R})^2}\right]\left[\frac{1}{1+\frac{\omega^2 C^2 rR^2}{R + r}}\right] \tag{3}$$

$$\gamma = \frac{v}{p} = \beta R_v \tag{4}$$

where ω is the angular frequency of operation and r, R, and C are defined in Figure 2.
β is the short circuit current sensitivity
p is the power level
γ is the open circuit voltage sensitivity
R_v is the diode video impedance, $\frac{1}{f'(V_0)}$
$a = \frac{g}{KT}$, a fundamental quantity

It should be pointed out that the preceding equations, which are based on various approximations, only approach experimental performance. Despite this, they enable one to gain some qualitative insight into video detector operation. The intent is not to establish a rigorous foundation of theory, but rather an appreciation of various parameters involved and how they affect operations.

For example, inspection of the diode equivalent circuit in Figure 2 and the expression for voltage and current sensitivity show that barrier capacitance, C, will have a detrimental shunting effect as the frequency of operation is increased. In an effort to overcome this, one can resort to the use of a diode having a lower capacitance value. Unfortunately, this is also accompanied by an increase in barrier resistance, R, and in many cases series resistance, r. As a result, overall performance could remain unchanged or become worse.

Detector Sensitivity

In the course of detecting low level signals, a theoretical limit is reached because of the random noise which is present in any system. In order to establish this limit, you must take into account various factors pertaining both to signal and noise generation. Figure 3 shows a schematic diagram of a video detector, complete with the generators, impedance values, etc. necessary for evaluation.

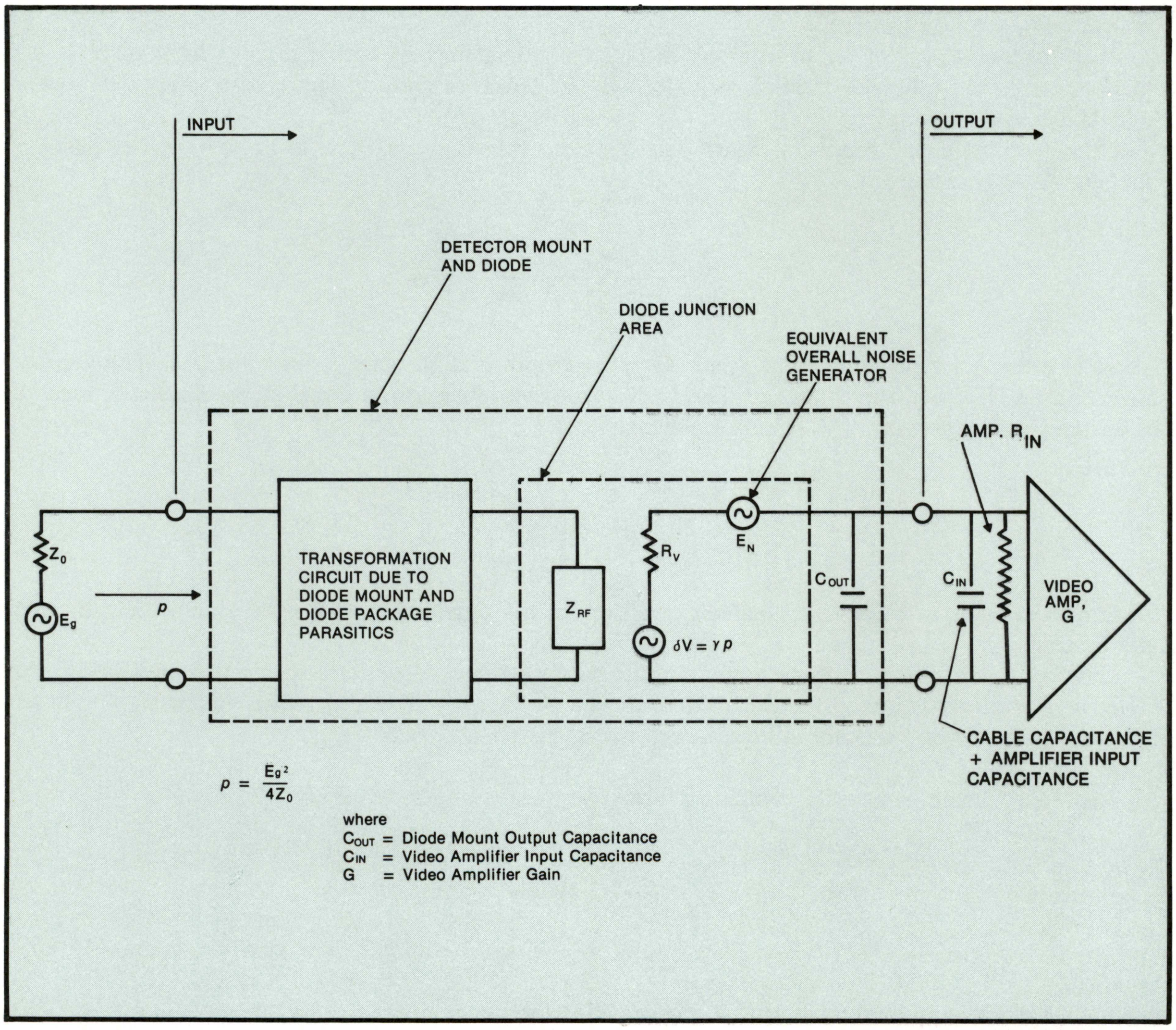

INPUT
OUTPUT
DETECTOR MOUNT AND DIODE
DIODE JUNCTION AREA
EQUIVALENT OVERALL NOISE GENERATOR
AMP. R_{IN}
Z_0
E_g
p
TRANSFORMATION CIRCUIT DUE TO DIODE MOUNT AND DIODE PACKAGE PARASITICS
Z_{RF}
R_V
E_N
$\delta V = \gamma p$
C_{OUT}
C_{IN}
VIDEO AMP, G
CABLE CAPACITANCE + AMPLIFIER INPUT CAPACITANCE
$p = \frac{E_g{}^2}{4Z_0}$
where
C_{OUT} = Diode Mount Output Capacitance
C_{IN} = Video Amplifier Input Capacitance
G = Video Amplifier Gain

FIGURE 3 - VIDEO DETECTOR SCHEMATIC REPRESENTATION FOR SENSITIVITY EVALUATION

APPLICATION NOTES - VIDEO DETECTORS & DIODE HOLDERS (Cont'd)

It will be assumed that maximum available power from the generator is delivered to the diode, Z_{RF}. In actual operation, this situation can be closely approached over a limited bandwidth through use of suitable matching structures.

In this discussion, the major criterion for sensitivity will be assumed to be a 3 dB increase over existing noise. This arbitrary value has been termed nominal detectable signal (NDS) and its advantage is that it is free from subjective considerations. The most common term encountered, tangential signal sensitivity (TSS), will also be used due to its widespread adoption.

Experiments have shown TSS to be 3 to 4 dB greater in power level than NDS.* Rather than a well defined condition such as NDS, tangential sensitivity has become accepted as that value of pulse signal which will cause the maximum noise peaks in the absence of signal to be equal to the minimum noise peaks during the signal period.

Still another term that has been employed is minimum detectable signal (MDS). As implied, it is defined as that level of signal sufficiently large to make its presence known. This rather vague definition has kept its use to a minimum.

Based on the circuit shown in Figure 3, a general expression for signal to noise at the amplifier output is given in equation (5).

$$\frac{\text{Signal}}{\text{Noise}} = \frac{V^2 G}{4R_v N} = \frac{G}{4R_v N}(\gamma p)^2 \tag{5}$$

where N is the noise power present at the amplifier output and all other terms have been previously defined. For an NDS condition, the signal and noise power levels must be equal as previously defined. Use of this and rearrangement of (5) yields equation (6).

$$\text{NDS} = \frac{2}{\gamma}\left[\frac{R_v N}{G}\right]^{1/2} \tag{6}$$

What now remains is to obtain a suitable expression for the amplified output noise due to both the diode and amplifier.

For the diode noise, two components must be considered. These are shot noise and flicker noise. Whereas the former is uniform and considered to be white noise over the frequency spectrum, the latter increases inversely as a function of frequency. It is often termed $1/f$ noise.

An approximate expression containing these two noise components is given in equation (7).

$$t = t_w + \frac{B_x}{f} \tag{7}$$

where
t = total diode noise temperature at a specific video frequency
t_w = white noise temperature
B_x = flicker noise constant characteristic of the particular diode
f = video frequency

---

*Vol. 23 of the Rad. Lab. Series says 8-dB S/N. MDS is –3 to +4 dB S/N.

Assuming that the amplifier gain and associated noise figure, F_V, are constant over the video bandwidth, equivalent input noise power at the amplifier output terminals can be calculated by use of equation (8).

$$N = \int_{f_1}^{f_2} G(f)df \left[kT_0 t + kT_0 (F_v - 1) \right] \tag{8}$$

where f_1 and f_2 represent the amplifier bandwidth frequency limits. Substituting equation (7) into (8) and integrating will yield an expression for noise power present at the amplifier output terminals.

$$N = GkT_0B\, t_w + \frac{B_x}{B} \ln \frac{f_2}{f_1} + F_v - 1 \tag{9}$$

where B is the amplifier bandwidth $(f_2 - f_1)$ and all other terms have been previously defined. Substituting this into equation (6) will yield the basic expression for detector sensitivity.

$$NDS = \frac{2}{\gamma} \left[kT_0BR_v(t_w + F_v - 1 + \frac{B_x}{B} \ln \frac{f_2}{f_1}) \right]^{1/2} \tag{10}$$

Unfortunately, this expression has seen little use to date in available literature on diode performance. Instead, the term figure of merit, M, continues to be the criterion of video detector diode performance. It is defined as

$$M = \frac{\gamma}{\left[R_v + R_N \right]^{1/2}} \tag{11}$$

where R_N is the equivalent input noise resistance of the amplifier and is standardized at a value of 1200 ohms, typical of a vacuum tube video amplifier in 1950. Figure of merit has failed to take into account a white noise temperature other than unity, $1/f$ noise characteristics, and realistic amplifier noise performance.

Before concluding this part of the discussion, a subtle point of concern to all those burdened with the responsibility of "interface" problems will be reviewed; that is, the effect of diode video impedance and detector mount capacitance on overall NDS performance. From a voltage sensitivity viewpoint, a high value of R_V is desired in addition to low noise operation of the video amplifier. Therefore, with specific amplifier characteristics (gain, input impedance, bandwidth, noise), a straightforward approach would be to vary diode forward bias current until best sensitivity is secured. Unfortunately, another effect, often forgotten, must be taken into account. In Figure 3 two capacitance values at the amplifier input are shown, C_{out} and C_{in}.* These can be considered to form a single value C_T. If the $C_T R_V$** product is too high, the bandwidth of the amplifier could be reduced from its designed value. The 3-dB point of the input section alone will depend inversely on $2\pi C_T R_V$. In effect, the amplifier bandwidth will differ from its pre-determined value, and sensitivity will appear greater as can be seen by inspection of equation (10). In extreme situations, this condition manifests itself in a high degree of pulse shape distortion in the form of long rise and fall times. If tests are performed using long pulses or square wave modulation of the RF signal, a condition such as this could go unnoticed. This aspect will be covered more thoroughly in subsequent discussion.

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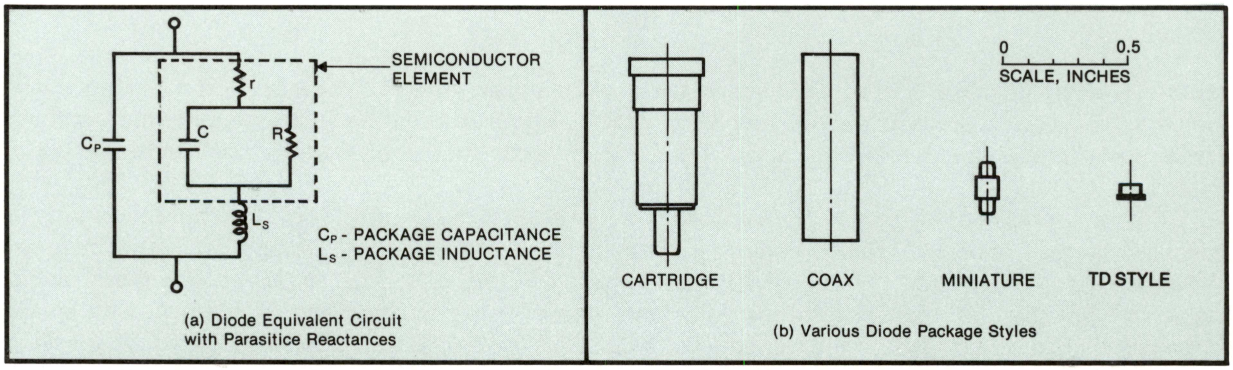
*C_{in} includes the capacitance of any cable used

**Here, $R_V = \frac{R_V R_{in}}{R_V + R_{in}}$ where R_{in} = Amplifier & R_L

VIDEO DETECTOR DIODES

The three diode types now in widespread use are point contact diodes, back diodes, and Schottky diodes. As with most competitive devices, each offers advantages over the others. This discussion assumes that all three diode types have similar equivalent circuits as shown in Figure 2, which also illustrates the general current-voltage characteristic curves. These curves show the point contact and Schottky diodes to have very similar characteristics, with the Schottky type having a higher voltage value at the "knee" of the curve. In the case of the back diode, which is essentially a tunnel diode selected for detection purposes, the negative portion of the curve exhibiting a high slope is the area of interest. Under normal operating conditions, the negative resistance area is not used.

In Figure 4, the diode equivalent circuit for all three types is shown. From an electrical viewpoint, the only difference lies in the resistance and reactance values associated with the semiconductor element. In addition, the major package parasitics, C_P and L_s, are shown. These are the shunt package capacitance and series package inductance respectively. Also illustrated in Figure 4 are typical diode package styles. The cartridge and coax types have been employed for many years; more recently, the miniature and "tunnel diode type" have been utilized. These latter two have the advantage of exhibiting lower parasitic reactance values; an important property when wide bandwidth match is desired.



(a) Diode Equivalent Circuit with Parasitice Reactances

(b) Various Diode Package Styles

FIGURE 4 - EQUIVALENT CIRCUIT & PACKAGE STYLES FOR DETECTOR DIODES

In order to present a qualitative picture of RF impedance for the various diode types, a comparison Smith chart impedance plot is shown in Figure 5. These typical curves are under low signal level conditions, and with a fixed $10\mu A$ bias for Schottky and point contact diode types. This nominal bias level is often encountered in actual practice though it can vary widely ($5\text{-}50\mu A$) depending on the particular set of circumstances encountered. Both point contact and Schottky diodes were housed in miniature packages and the back diode in a tunnel diode type package. These are shown in Figure 4. All were mounted in 50-ohm holders that were previously tested for good intrinsic match. Not evident from Figure 5 is the effect of package parasitics, especially series inductance. Had a larger diode package been used, each curve would have traveled farther clockwise at any given frequency due to series resonance of the junction capacitance and parasitic inductance occuring sooner. Junction capacitance associated with the point contact, Schottky, and back diodes of Figure 5 are estimated to be 0.09, 0.16, and 1.0 *pf* respectively. These values are based on typically known diode characteristics, associated parasitic reactance values, and estimates from Figure 5 on the series resonant frequencies.

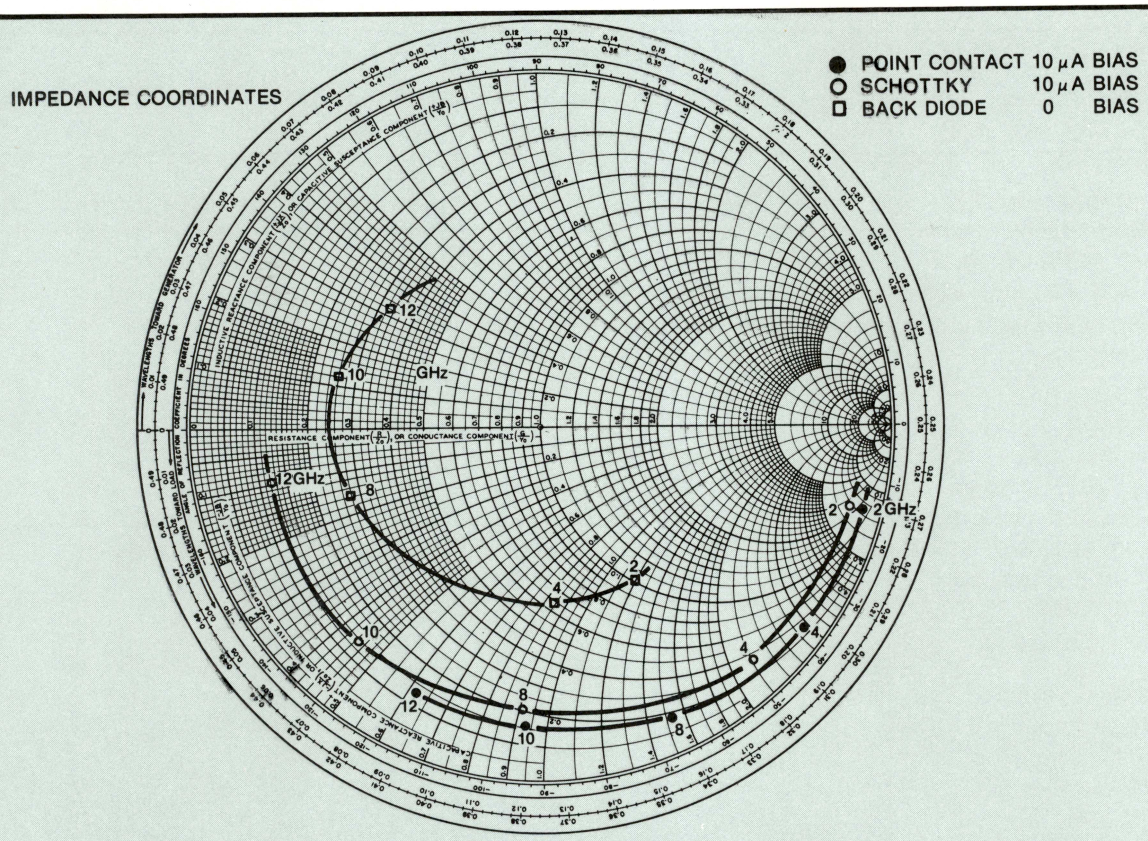


FIGURE 5 - TYPICAL DIODE IMPEDANCE PLOTS

R_L = 1 K-ohm P = −20 dBm

From an RF impedance viewpoint, one can appreciate the lower impedance characteristics of the back diode. Its highest VSWR over the 2-12 GHz frequency range is only 4 while the other two types exhibit values of greater than 20. This feature makes it an ideal diode type when moderate VSWR values are desired over a broad bandwidth. When contained in an appropriate diode mount with DC return, a maximum VSWR of 4.5 can be obtained over the 2-12 GHz frequency range. This has been achieved with no resistive padding. Performance such as this with either the point contact or Schottky diode can only be achieved over narrower frequency ranges such as octave bandwidths. To overcome this in part, increased bias can be utilized to lower the diode impedance. Tests have shown that improvements from 30-13 in VSWR can be obtained for Schottky diodes when bias is increased from 10-50 μA at 2 GHz. Unfortunately, some sacrifice in sensitivity results, due primarily to the reduction in video impedance. Despite these apparent advantages, the point contact and Schottky diode can still be considered competitive due to their higher inherent sensitivity. Therefore, some degree of sacrifice in sensitivity due to high mismatch or large bias values can be tolerated.

From prior discussion, it becomes evident that no clear cut decision with regard to diode choice exists. Each diode classification offers unique advantages and a final choice is most often dictated by the particular set of specifications desired. Therefore, a comparison of diode types with regard to various parameters of interest would serve as an aid in any overall comparison. This is presented in Table I.

TABLE I
COMPARISON OF TYPICAL DIODE CHARACTERISTICS

CHARACTERISTIC	**POINT CONTACT DIODE**	**SCHOTTKY DIODE**	**BACK DIODE**
TSS - compared at 12 GHz with a 10 MHz video bandwidth (matched)	−53 dBm	−55 dBm	−48 dBm
Bias considerations	10-50μA range, usually required for best performance	5-20μA range must be employed	100μA will typically yield 1.5 dB improvement in TSS
Inherent RF impedance (VSWR characteristics at −20 dBm) $Z_0 = 50$ ohms	20 @ 2 GHz 6 @ 12 GHz with 10μA bias	20 @ 2 GHz 5 @ 12 GHz with 10μA bias	Low impedance Typically 3 to 5
Typical detected voltage output at 12 GHz with a 1000 ohm load (−20 dBm)	1.5 mV	0.2 mV	8 mV
Flicker noise (1/*f*) characteristics	High below 100 KHz	Moderately low down to 10 KHz	Very low
Burn out capability, cw	Good 200-300 mw	Very good 300-400 mw	Poor to fair 100-200 mw
Reproducibility of diode for matched detector pair applications	Poor to fair	Good	Good
Video impedance characteristics	1500-10000 ohms @10-50 μA bias	4000-30000 ohms @10-50μA bias	100-300 ohms @ zero bias

APPLICATION NOTES - VIDEO DETECTORS & DIODE HOLDERS (Cont'd)

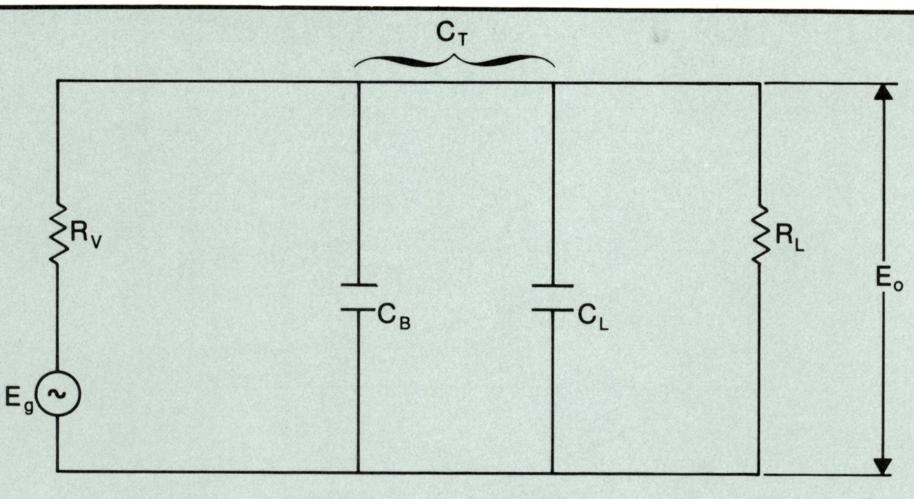
VIDEO DETECTOR DESIGNS

The RF Bypass Capacitor

The RF bypass capacitor serves the sole purpose of presenting a short circuit to RF energy. In addition, however, it must be sufficiently low in value so as not to effect video bandwidth. This effect is impossible to eliminate completely, but it can be minimized. The minimum value of capacitance required to achieve proper shorting action depends on two main factors. These are the RF frequency of operation and the diode RF impedance level. Therefore, the type of diode can influence greatly the value of minimum bypass capacitance required.

In Figure 6, the equivalent circuit interface between the video detector and amplifier is illustrated. The relationship of source voltage from the equivalent diode generator, E_g, and voltage at the input terminals of the amplifier, E_o, can be expressed as shown in equation (12)

$$\frac{E_g}{E_o} = \frac{R_v + R_L}{R_L} + j\,\frac{R_v}{X_T} \qquad (12)$$



Where R_V = Diode Video Impedance
C_B = Diode Mount Bypass Capacitance
R_L and C_L = Amplifier Input Resistance and Capacitance

FIGURE 6 - EQUIVALENT VIDEO CIRCUIT OF INTERFACE BETWEEN DIODE AND AMPLIFIER

Inspection shows that at very low video frequencies where $X_T \gg R_v$, R_v and R_L form a simple voltage divider network. As video frequency increases, the ratio E_g/E_o will increase. The 3 dB point in response is reached when the two terms of equation (12) are equal in magnitude. This relationship yields the video interface bandwidth as shown in equation (13).

$$f_v = \frac{R_L + R_V}{R_L R_V 2\pi C_T} = \frac{1 + R_L/R_V}{2\pi R_L C_T} = \frac{1 + R_V/R_L}{2\pi R_V C_T} \qquad (13)$$

where f_v is the 3 dB interface circuit bandwidth frequency and all other terms have been previously defined.

In Figure 7, three series of plots for equation (13) are presented. Each series is for a specific value of R_L. R_v is varied to show the effect of bypass capacitance, which is considered as the total value C_T. These plots show that from a video bandpass viewpoint, R_L and C_T should be made as low as possible.

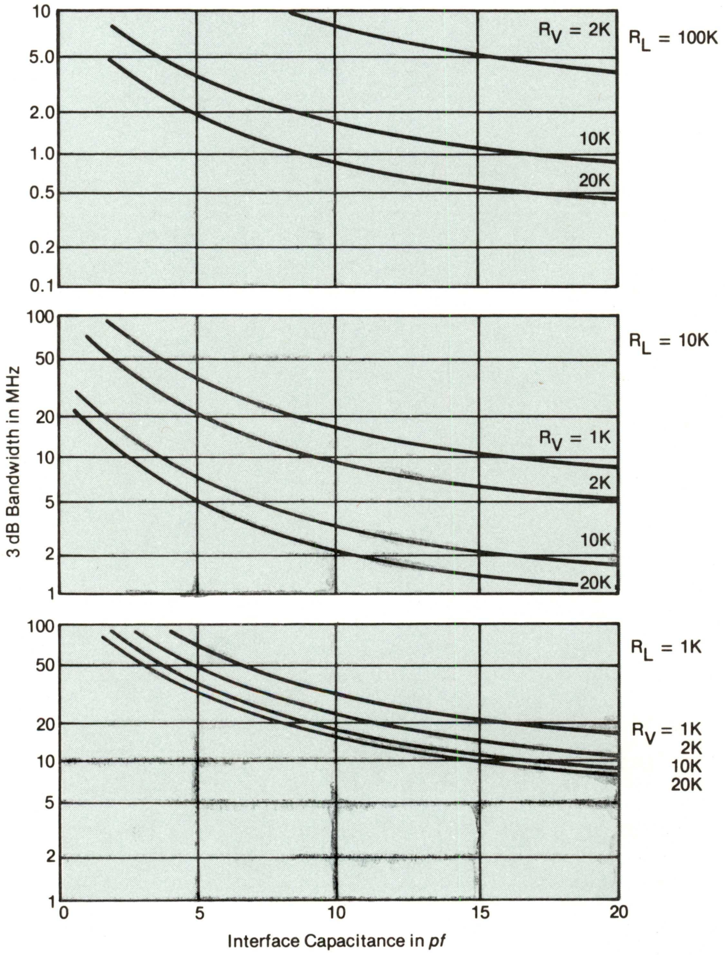


FIGURE 7

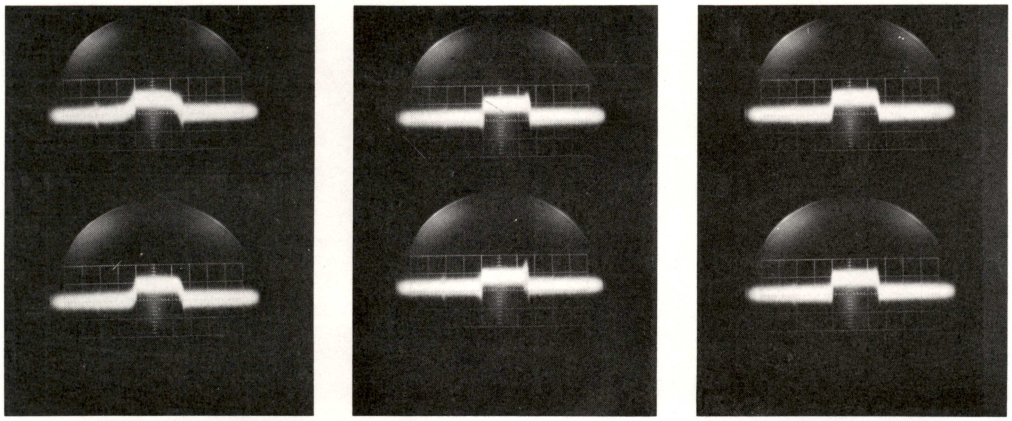
PLOTS OF INTERFACE VIDEO BANDWIDTH CHARACTERISTICS AS A FUNCTION OF INTERFACE CAPACITANCE, C_T, AND AMPLIFIER INPUT RESISTANCE, R_L, FOR VARIOUS VALUES OF VIDEO RESISTANCE, R_V.

APPLICATION NOTES - VIDEO DETECTORS & DIODE HOLDERS (Cont'd)

In Figure 8, a series of scope displays show the performance of a Schottky diode video detector under various bias conditions. At very low bias levels, 1 and 2.5μA, pronounced rise and decay times are evident for the detected pulse under TSS conditions. As bias is increased, the pulse becomes sharper but TSS is reduced. For the 2.5μA condition, rise time is approximately 1.0μs. These can be related to overall 3 dB system bandwidth by the approximate expression in equation (14).

$$B \approx \frac{0.35}{t} \tag{14}$$

where t is rise time. From this expression an overall bandwidth of 350 KHz is obtained. The video amplifier utilized had a bandwidth of 10 MHz and input resistance of greater than 500 K ohms; hence, the effect of interface video bandwidth limiting is well demonstrated. Assuming a video impedance of 20 K and a measured total capacitance value of 30 *pf*, equation (14) yields a 3 dB bandwidth of 275 KHz. This lies well within the general vicinity of the value computed from the detected pulse display in Figure 8 and equation (14).



46.8 dB@1μA
47.5 dB@2.5μA

47.4 dB @ 5μA
47.5 dB @10μA

46.2 dB@25μA
45.3 dB@75μA

FIGURE 8

SCOPE DISPLAYS OF TSS SIGNAL LEVELS FOR A SCHOTTKY DIODE UNDER VARIOUS BIAS CONDITIONS (AMPLIFIER BANDWIDTH = 13.4 MHz . . . HORIZONTAL SCALE ~ 5 μSEC/CM)

Physical realization of the bypass capacitor most often takes the form of a small low impedance coaxial slug which is usually dielectric-filled to increase capacitance. For most applications this design is adequate. It can be considered as a lumped capacitor except when its electrical length approaches a quarter wavelength. If this occurs, a drastic deviation from proper shorting action can take place.

As a final comment in this area, it should be kept in mind that the overall system video bandwidth will be less than that exhibited by each stage. Therefore, adequate bandwidth should be provided in the video amplifier and at the detector-amplifier interface, so that the composite value can meet specified requirements.

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3 Huron Drive
Natick, MA 01760 U.S.A.
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Shipments are made in the most economical way that is convenient to you. Your specific instructions regarding method of shipment and routing will be satisfied through the many excellent transportation facilities readily available at our facility. All forms of transportation via mail, truck, or air are available at your discretion.

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The Sage New Product Album

This is a year to remember . . . with Sage very active in passive components, amplifiers and solving tough system problems.

These products are new additions since our 1978 catalog.

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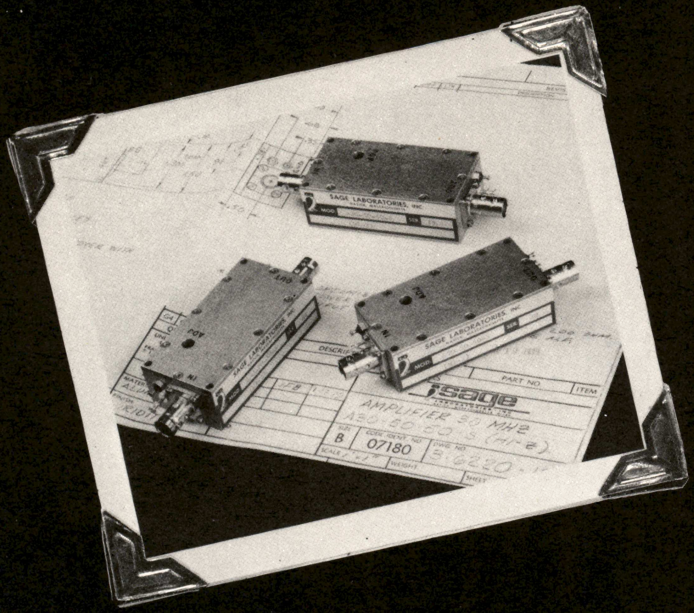
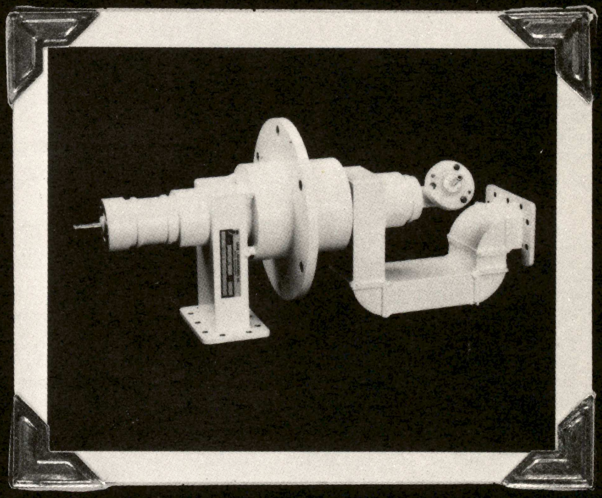


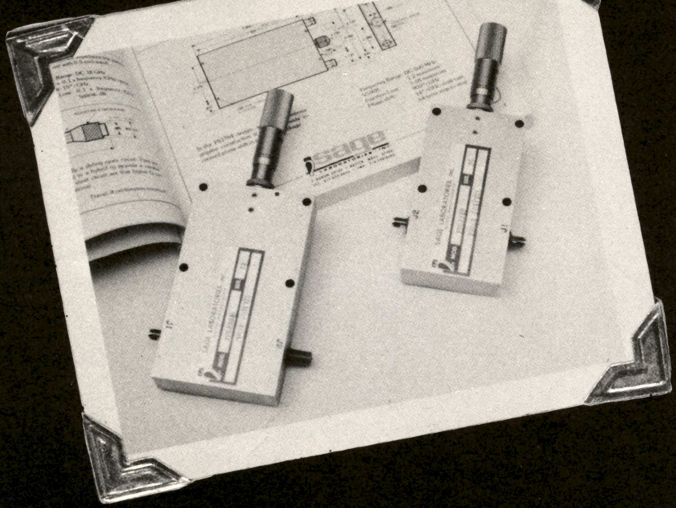
VARIABLE INPUT IMPEDANCE AMPLIFIER — A-30-50-50-S

Noise Figure: Below 1.5dB
Resistive Source Impedance: 50 to 450 ohms
Overall Gain: 50dB Minimum
3 dB Bandwidth: More Than 10MHz
Output Impedance: 50 ohm

DUAL CHANNEL ROTARY JOINT — FRJ2459

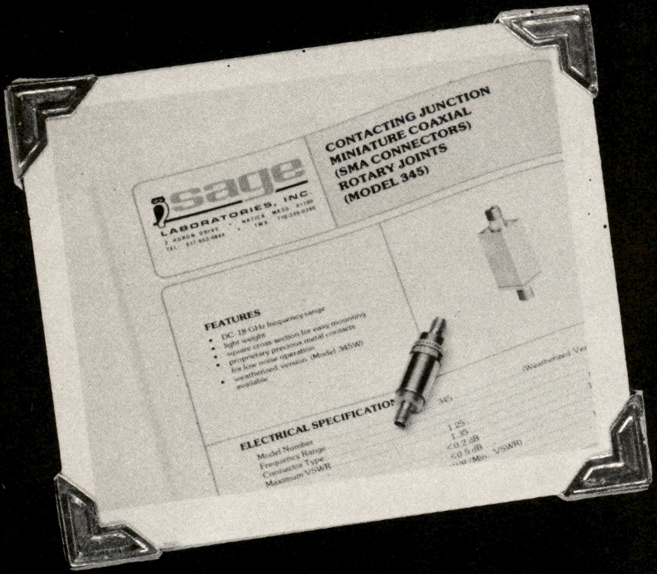
Covers: 2.7 to 2.9 GHz
Waveguide Channel: Rated 1MW Peak, 1.5 KW Average Power with Less Than 0.1dB Insertion Loss
7/8 Inch Coaxial Channel: Rated 5KW Peak, 50 Watts Average Power
VSWR: Less Than 1.25/1





STRIPLINE PHASE SHIFTERS — FPS2212 and FPS2331

Qualified for UHF and S-Band Portions of AEGIS Radar System
Tested for: Vibration, Salt Spray, Humidity, Temperature Operation
Meets Tight Phase Linearity and Unit-to-Unit Tracking Specifications
Low VSWR and Insertion Loss: Preserves System Phase Linearity



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CONTACTING JUNCTION
MINIATURE COAXIAL
(SMA CONNECTORS)
ROTARY JOINTS
(MODEL 345)

FEATURES
- DC-18 GHz frequency range
- light weight
- square cross-section for easy mounting
- proprietary precious metal contacts for low noise operation
- weatherized version (Model 345W) available

ELECTRICAL SPECIFICATION

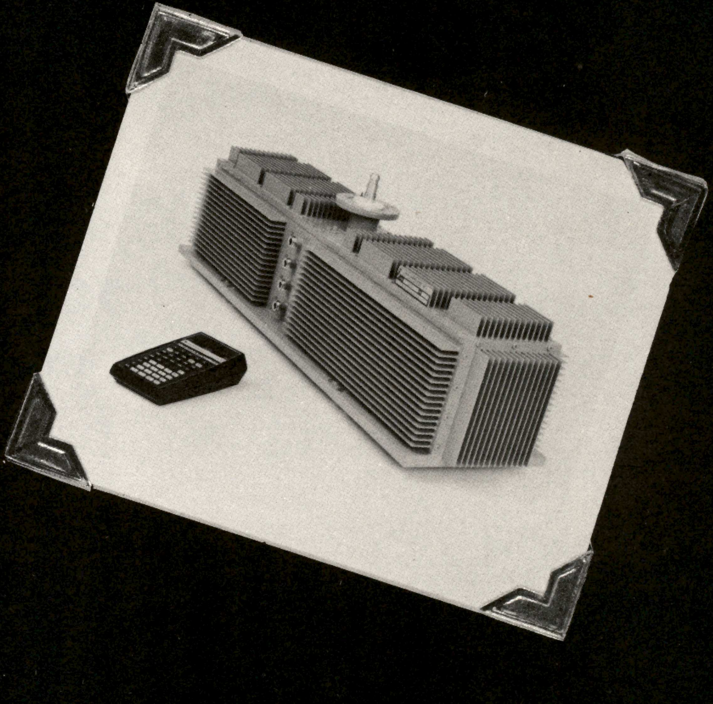
Model Number
Frequency Range
Connector Type
Maximum VSWR

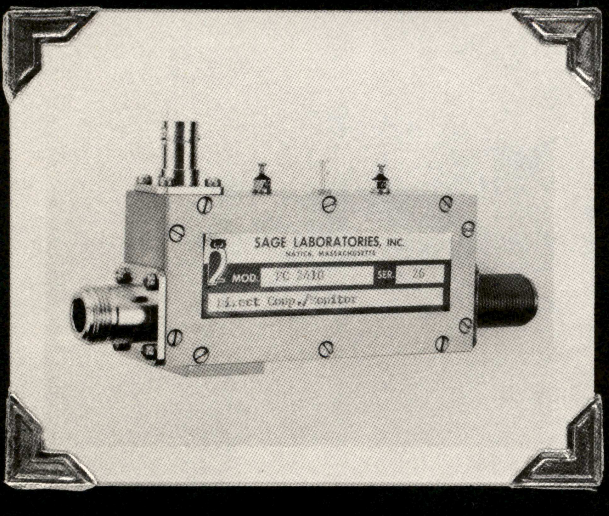
1/2 INCH DIAMETER ENVELOPE ROTARY JOINT — 345C

DC-18GHz
Threaded Outer Body Screws Directly Into Gimbal
VSWR: 1 + .07 f (GHz)
Insertion Loss: .02 f (GHz) dB

HIGH POWER DIVIDER — FP2546

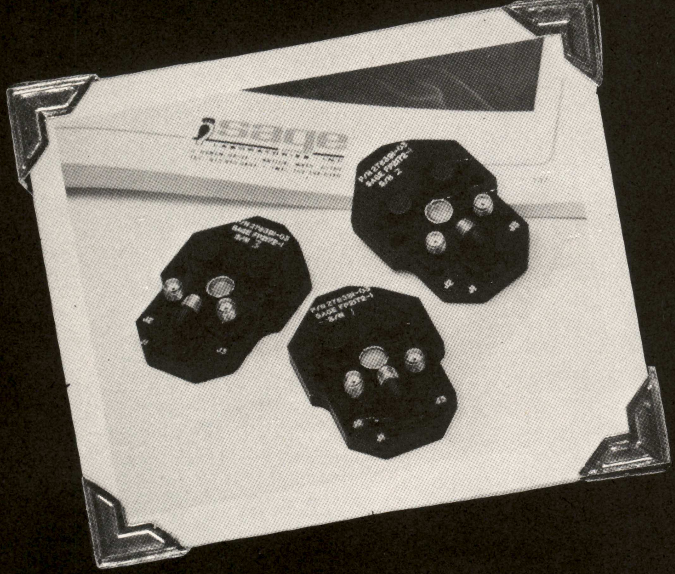
8-Way Power Dividers
4 Outputs: 1/6 Input Power
4 Outputs: 1/12 Input Power
Input Power Rating: 50KW Peak, 5.4 KW Average at 1.5/1 Load
Frequency Band: 205 to 225 MHz
Input VSWR: 1.13/1 Maximum
Insertion Loss: 1.17 dB





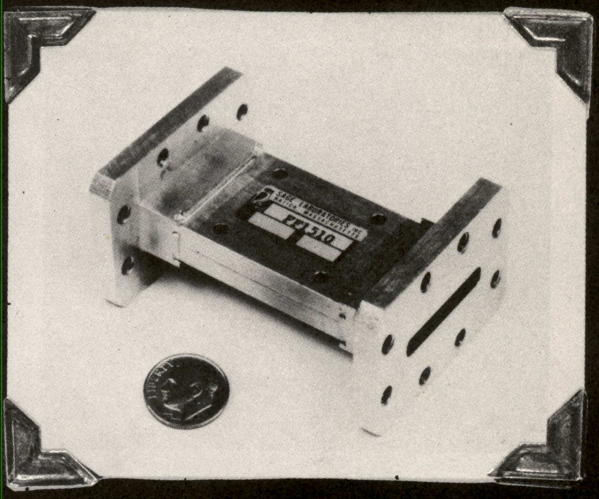
COUPLER-DETECTOR — FC2410

Operates From: 990 to 2020 MHz
30dB Forward Power Sampling Port
Forward and Reverse Power Video Detectors
Operates At 100 Watts CW Main Line Power
Main Line and Sampled Output VSWRs: Less Than 1.15/1
Main Line Insertion Loss: Less Than 0.2dB



SATELLITE QUALIFIED POWER COMBINER — FP2172-1

In-phase Combining of 2 10-Watt 3.9 to 4.1 GHz Signals
Loss: Less Than .2 dB
VSWR: Less Than 1.17/1
Input VSWR: Controlled from 2 to 5 GHz
Isolation of the Input Signals: Extends from DC to 5 GHz, Greater
Than 20 dB from 3.7 to 4.2 GHz
Built-in Terminations Reliably Dissipate Full Input Power in the Event
of Loss of Driver Phase or Loss of One Input



WAVEGUIDE LOW PASS FILTER — FF1510

Insertion Loss: Less Than 0.1dB Over the 7.23 to 7.45 GHz Passband
Operable from 6.4 to 8.0 GHz
Second and Third Harmonics of 7.23 to 7.45 GHz Signals Rejected
By Greater Than 60 dB
General Rejection: 40 dB Minimum from 10 to 24.5 GHz
Transmits: 2 KW C-W
Length: Less Than 3 Inches
Designed and Qualified: NATO III Communications Satellite

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3 Huron Drive, Natick, Massachusetts 01760 • 617/653-0844 • TWX: (710) 346-0390

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Domestic Price List
September 1, 1979

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MINIMUM ORDER

The minimum order charge is $100.

PHASE SHIFTERS

Model No.	Unit Price
597B	$250
FS580	250
635	500
FS1783	600
FS1784	650
6501	495
6502	495
6503	495
6504	520
6505	520
6506	520
6507	550
6508	580
6509	495
6510	550

FILTERS

Model No.	Unit Price
FF9482-1	$460
FF9482-2	460
FF9482-3	520
FF9482-4	520
FF9482-5	520
FF9482-6	460
FF9482-7	460
L20CA072	95
L30CA073	95
L40CA074	95
L60CA046	95
L80CA047	95
L10MA048	95
L12MA049	95
L18MA050	95
L20CA104	115
L30CA105	115
L40CA114	115
L60CA115	115
L80CA116	115
L10MA117	115
L12MA112	115
L18MA111	115
25X50XA376	250
50X10CA377	200
10C20CA378	195
20C40CA379	195
40C80CA427	225
80C12MA425	275
W10MA	470
W10MB	550
W12MA	470
W12MB	550
W15MA	530
W15MB	605
W18MA	530
W18MB	605
W26MA	580
W26MB	660

D. C. BLOCKS

Model No.	Unit Price
505F	$250
5504	105
5504F	105
5504M	105

SWITCHES

SA Series

Model No.	Unit Price
SAN2180 E or H	$290
SAT2180 E or H	295
SAB2180 E or H	300
SAM2180 E or H	310
SAC2180 E or H	310
SAH2180 E or H	310
SAN3120 E or H	300
SAT3120 E or H	305
SAB3120 E or H	310
SAM3120 E or H	315
SAC3120 E or H	315
SAH3120 E or H	315
SAN 490 E or H	310
SAT 490 E or H	315
SAB 490 E or H	320
SAM 490 E or H	335
SAC 490 E or H	335
SAH 490 E or H	335
SAN 660 E or H	320
SAT 660 E or H	325
SAB 660 E or H	330
SAM 660 E or H	375
SAC 660 E or H	375
SAH 660 E or H	375

Manual

Model No.	Unit Price
2 Position	$260
3 Position	290
4 Position	305
6 Position	315

Fail Safe

Model No.	Unit Price
SAN260E-FS	$340
SAN260H-FS	460
SAM260E-FS	405
SAM260H-FS	520

SB Series

Model No.	Unit Price
SBN490 E	$230
SBH490 E	260
SBB490 E	230
SBT490 E	235
SBC490 E	275
SBM490 E	290

SF Series

Remote

Model No.	Unit Price
SFN490 E or H	$460
SFB490 E or H	460
SFT490 E or H	460
SFM490 E or H	490
SFH490 E or H	490
SFC490 E or H	490

Manual

Model No.	Unit Price
SFN490	$340
SFB490	340
SFT490	340
SFM490	375
SFH490	375
SFC490	375

SHM Series

Model No.	Unit Price
SHM3120EC	$360
SHM460/120EC	415
SHM560EC	470
SHM660EC	495

SK Series

Model No.	Unit Price
SKM/EA	$325
SKM/EB	325
SKM/EE	325
SKM/EF	325
SKM/EG	325
SKM/EH	325

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ST Series

Model No.	Unit Price
STN2180A	$105
STB2180A	105
STT2180A	110
STM2180A	120

AMPLIFIERS/ PREAMPLIFIERS

Model No.	Unit Price
A-15-60-1C-3	$545
A-30-26-5	405
A-45-32-1C-3	545
A-45-48-2C	545
A-70-8-1C	545
A-70-26-5	375
A-70-45-1C-3	430
A-70-50-1C-1	405
A-70-52-1C-3	460
A-70-34-40	545
A-90-26-5	375
A-150-18-10	490
A-200-18-10	490
A-700-18-10	545
A-1300-15-5	545
A-30-50-50	340
A-30-50-50-1	375
A-30-50-50-2	405
A-30-50-50-3	430
A-30-50-1C-3	460
A-30-50-2C	405
A-30-50-2C-1	430
A-30-50-2C-2	460
A-45-50-50	375
A-45-50-50-1	405
A-45-50-50-2	430
A-45-50-1C	460
A-45-50-1C-1	490
A-45-50-1C-2	520
A-60-50-50	375
A-60-50-50-1	405
A-60-50-50-2	430
A-60-50-50-3	460
A-60-48-1C	490
A-60-48-1C-3	520
A-70-50-50	375
A-70-50-50-1	405
A-70-45-50-1	430
A-70-50-1C-3	545
A-15-19-30	490
0A-15-19-25	520
A-30-19-30	490
0A-30-19-30	520
A-30-24-30	520
A-45-15-30	545
0A-45-15-25	545
A-45-19-30	490
A-60-19-30	490
0A-60-19-25	520
A-70-15-50	545
A-70-19-30	490
A-120-19-30	545
A-150-19-30	545

MIXER-PREAMPLIFIERS

Model No.	Unit Price
MPL750-A-15	$1035
MPS750-A-15	1065
MPC750-A-15	1120
MPX750-A-15	1265
MPK750-A-15	1440

TEMLINE MIXERS

Model No.	Unit Price
2491A	$525
2491	525
2493	525
2501A	495
2501	495
2503	495
2511A	440
2511	440
2513	440
2521A	385
2521	385
2523	385
2531A	385
2531	385
2533	385
2541NDA	385
2541ND	385
2543ND	385
2551A	550
2551	550
2553	550

M-LINE MIXERS

Model No.	Unit Price
22511A	$385
22511AS	415
22513	385
22513S	415
22521A	305
22521AS	315
22521AT	325
22523	305
22523S	315
22523T	325
22521EA	305
22521EAS	315
22521EAT	325
22523E	305
22523ES	315
22523ET	325
22531A	305
22531AS	315
22531AT	325
22533	305
22533S	315
22533T	325
22541A	330
22541AS	340
22541AT	350
22541AV	360
22543	330
22543S	340
22543T	350
22543V	360
22551KA	385
22551KAS	395
22551KAT	405
22553K	385
22553KS	395
22553KT	405
22651A	415
22651AS	425
22651AT	430
22651AV	435
22651AW	440
22653	415
22653S	425
22653T	430
22653V	435
22653W	440

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Model No.	Unit Price
22661A	495
22661AS	505
22661AT	515
22661AV	530
22663	495
22663S	505
22663T	515
22663V	530

ROTARY JOINTS

305W	$120
305WF	150
344	180
344F	210
345	210
345W	220
345C	210
334	Factory Quote
330	Factory Quote
343A	690
343F	660

TERMINATION

9217	$27
9217F	27
9200	22
9200F	22
9202	50
9202F	50
9203	50
9203F	50
9210	40
9210F	40
9211	65
9211F	65
9212	65
9212F	65
9213	65
9213F	65
9400	55
9400F	55
9402	85
9402F	85
9403	85
9403F	85
9404	85
9404F	85
9405	100
9405F	100

Model No.	Unit Price
9600H	45
9600HF	45
9602H	55
9602HF	55
9603H	50
9603HF	50
9800J	350

ATTENUATORS

9990-3	$175
9990-6	175
9990-10	175
9990-20	175

POWER DIVIDERS

FP1512-12	$160
FP1512-24	160
FP1512-48	160
FP2369-2	175
FP2369-4	160
FP2369-1	160
FP2369-5	160
FP1513-12	200
FP1513-24	200
FP1513-48	200
FP1835-12	290
FP1835-24	290
FP1835-48	290
FP2066-1	230
FP2066-2	750
FP2066-3	430
FP2383-1	175
FP2383-2	270
FP2380-1	160
FP2380-2	200
FP2380-3	230
FP2380-4	660
FP2380-5	1725
FP2381-1	260
FP2381-2	375
FP2382-1	160
FP2382-2	200
FP2382-3	290
FP2382-4	340

Model No.	Unit Price

(WIRELINE HYBRIDS are listed on Page 8.)

MINIATURE OCTAVE-BAND QUADRATURE HYBRIDS

DC751	$115
D 751	115
DC752	115
D 752	115
DC752E	140
D 752E	140
DC753	140
D 753	140
DC753E	140
D 753E	140
DC754	175
D 754	175
DC754E	185
D 754E	185
DC755	225
D 755	225
DC756	245
D 756	245
DC756E	290
D 756E	290

MINIATURE MULTI-OCTAVE 3DB HYBRIDS

2375-1	$225
2376-1	225
2375-2	260
2376-2	260
2375-3	270
2376-3	270
2375-4	280
2376-4	280
2375-5	305
2376-5	305
2375-6	490
2375-7	545
2375-8	460

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Model No.	Unit Price
2375-9	520
2375-10	520

COBRIDS

Model No.	Unit Price
706	$550
705	550
702	550
711	550
701	550
710	550
704	550

TEMLINE HYBRIDS

Model No.	Unit Price
748	$430
749	375
750	225
751	215
752	215
753	240
754ND	315
755	375

MINIATURE H-STYLE DIRECTIONAL COUPLERS

Model No.	Unit Price
C-751-6	$130
C751-10	130
C751-20	130
C751-30	145
C752-6	145
C752-10	145
C752-20	145
C752-30	160
C752E-6	145
C752E-10	145
C752E-20	145
C752E-30	160
C753-6	145
C753-10	145
C753-20	145
C753-30	160
C753E-6	155
C753E-10	155
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C753E-30	175
C754-6	155
C754-10	155
C754-20	155
C754-30	175
C754E-6	175
C754E-10	175
C754E-20	175
C754-30	200
C755-6	245
C755-10	245
C755-20	245
C755-30	275
C756-6	275
C756-10	275
C756-20	275
C756-30	300
C756E-6	300
C756E-10	300
C756E-20	300
C756E-30	320

MINIATURE IN-LINE DIRECTIONAL COUPLERS

Model No.	Unit Price
D751-6R	$145
D751-10R	145
D751-20R	145
D751-30R	155
D752-6R	155
D752-10R	155
D752-20R	155
D752-30R	175
D752E-6R	155
D752E-10R	155
D752E-20R	155
D752E-30R	175
D753-6R	155
D753-10R	155
D753-20R	155
D753-30R	175
D753E-6R	165
D753E-10R	165
D753E-20R	165
D753E-30R	185
D754-6R	165
D754-10R	165
D754-20R	165
D754-30R	185
D754E-6R	185
D754E-10R	185
D754E-20R	185
D754E-30R	215
D755-6R	260
D755-10R	260
D755-20R	260
D755-30R	290
D756-6R	290
D756-10R	290
D756-20R	290
D756-30R	310
D756E-6R	310
D756E-10R	310
D756E-20R	310
D756E-30R	330

MINIATURE ULTRA BROADBAND DIRECTIONAL COUPLERS

Model No.	Unit Price
C112-6	$490
C112-10	490
C112-16	490
C112-20	490
C118-6	545
C118-10	545
C118-16	545
C118-20	545
C218-6	615
C218-10	615
C218-16	615
C218-20	615

TEMLINE COUPLERS

Model No.	Unit Price
748-3	$455
749-3	395
750-3	245
751-3	235
752-3	235
753-3	265

OCTAVE BAND HIGH POWER COUPLERS

Model No.	Unit Price
783-10	$575
783-20	575
783-30	575

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COMPACT COMMUNICATION BAND COUPLERS

Model No.	Unit Price
7901-20	$275
7901-30	275
7901-40	275
7901-50	275

OCTAVE BAND HIGH POWER COUPLERS

Model No.	Unit Price
7800-20	$250
7801-20	385
7802-20	330
7803-20	275
7810-20	235
7820-20	215
7800-30	250
7801-30	385
7802-30	330
7803-30	275
7810-30	235
7820-30	215

VIDEO DETECTORS

Model No.	Unit Price
D25S106	$275
D25B300	275
D25S300	275
D2S300	200
D3S300	200
D4S300	200
D5S300	200
D6S300	200

COAXIAL & WAVEGUIDE CRYSTAL HOLDERS

Model No.	Less Xtal or DC Return	With DC Return	With Crystal	With Xtal and DC Return
1021	$40	$50	$45	$60
1022	80	90	85	100
1023	40	50	45	60
1026	80	90	85	100
1262	80	90	85	100
1071	80	90	105	115
1072	80	90	105	115
1073	80	90	105	115
1231	70	80	105	115
1011	40	50	70	80
1012	80	90	85	100
1013	80	90	85	100
1016	80	90	85	100
1332	80	90	85	100
1221	70	80	115	125
1222	80	105	140	150
1352	90	105	140	150

Model No.	With Crystal	Less Crystal
1161	$340	$330
1151	340	330
1141	315	305
1641	290	255
1031	260	255
1081	265	230
1121	290	285
1111	290	285
1131	290	285
1171	315	305
1531	315	290
1041	260	225
1091	265	230
1701	265	230
1051	260	225
1101	265	230
1741	405	340
1061	320	290
1751	405	340

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WIRELINE HYBRIDS

Model No.	H Series	HC Series	HB Series	JB Series	JC Series
50-100	$22	$23	$24	$30	$30
60-120	20	21	22	27	27
70-140	18	19	20	24	24
80-160	17	18	19	22	22
90-180	16	17	18	20	20
100-200 thru 120-240	15	16	17	18	18
130-260 thru 200-400	13	14	15	16	16
210-420 thru 290-580	12	13	14	15	15
300-600 thru 370-740	11	12	13	14	14
380-760 thru 1400-2800	10	11	12	13	13

BULK WIRELINE

BH00	$10/Foot
BHC00	$11/Foot
BHB00	$12/Foot
BJB	$16/Foot
BJC	$16/Foot

(Minimum order of 10 feet)

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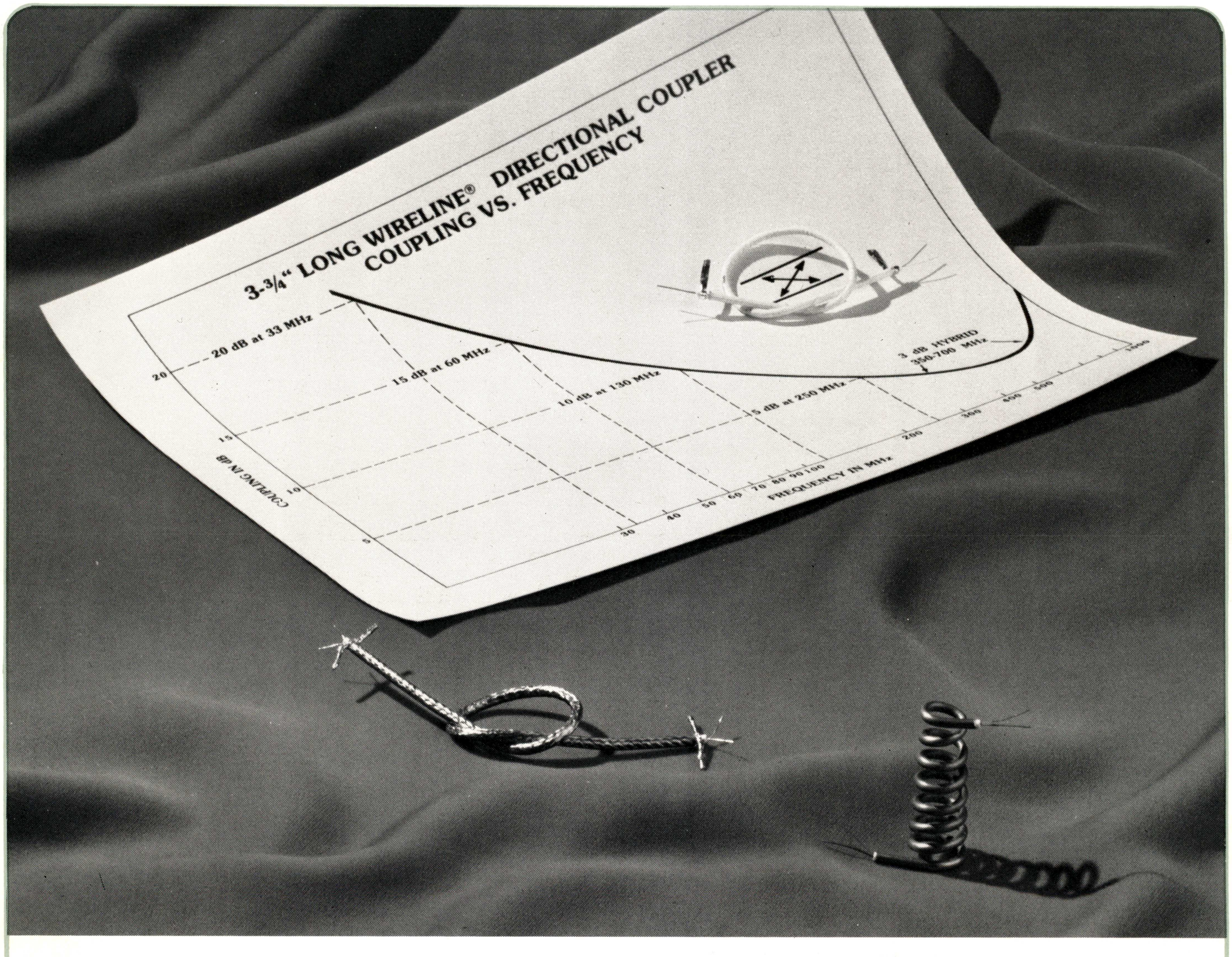
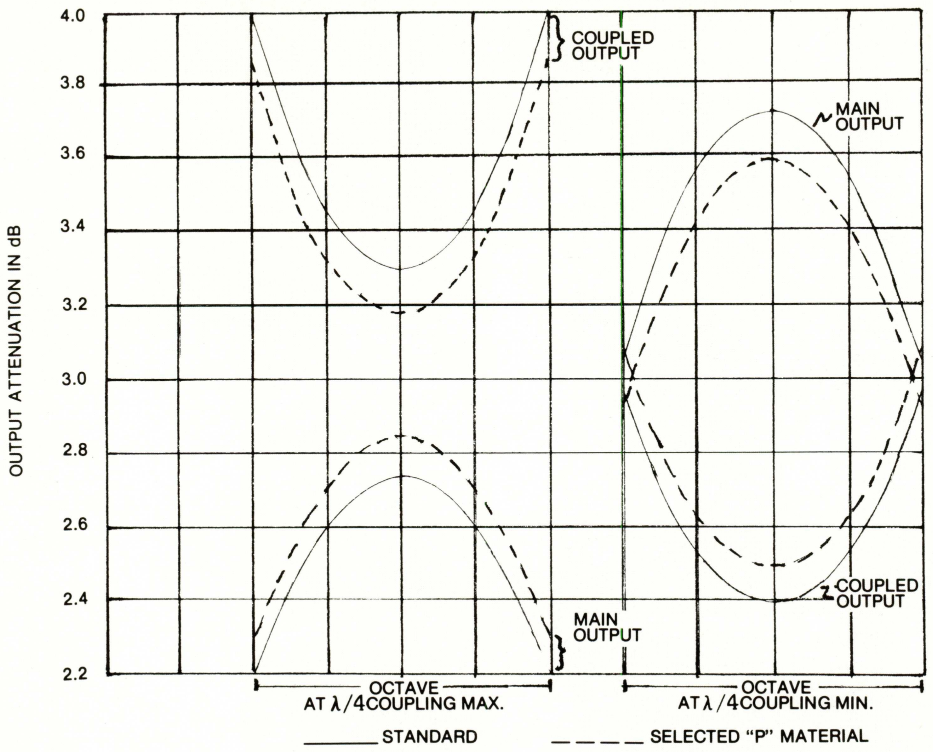
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (FLEXIBLE CABLE-LIKE CONSTRUCTIONS OF TEMLINE®)


3-3/4" LONG WIRELINE® DIRECTIONAL COUPLER
COUPLING VS. FREQUENCY
20 dB at 33 MHz
15 dB at 60 MHz
10 dB at 130 MHz
5 dB at 250 MHz
3 dB HYBRID
350-700 MHz
COUPLING IN dB
20
15
10
5
FREQUENCY IN MHz
30
40
50
60
70
80
90
100
200
300
400
500
1000

WIRELINE® couplers handle like wire, yet perform like machined couplers. The original WIRELINE units introduced by Sage Laboratories in 1968 have shown themselves to be a boon to designers in terms of design flexibility and cost reduction. Now we are pleased to offer two new additional WIRELINE styles — the JB and JC models which will handle 200 Watts C.W. power. Both new types also can be soldered into your system easily, and the solid copper style holds whatever shape you may wish to form. For all five WIRELINE styles, the tightest nominal coupling is 3 dB (quadrature hybrid at midband), which is obtained with a length equal to a quarter-wavelength. Shorter lengths yield looser coupling.

12/79

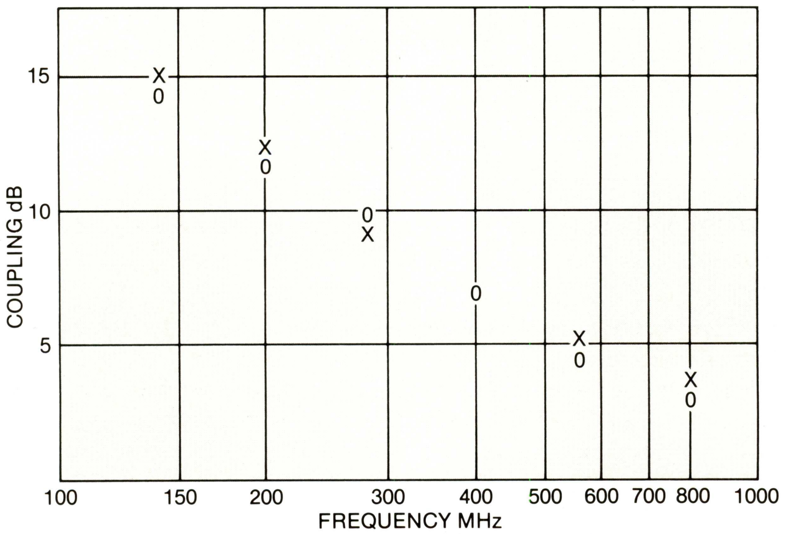
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)



Typical Coupling vs. Frequency (less Insertion Loss) of Specification Limit Hybrids
Note: Check factory for availability of selected "P" material.

Parallel Operation for Lower Impedance, Higher Power Systems.

WIRELINE hybrids can be connected in parallel to obtain higher power, lower impedance operation. i.e. two in parallel would give 25 ohms, three in parallel, 16 ohms, four in parallel 12.5 ohms, etc.



Test data on a short segment of Wireline demonstrating the close agreement between theoretical and measured curves. 0 = Measured, X = Theoretical.

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WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)

SPECIFICATIONS

STANDARD TOLERANCES & RATINGS AT 300 MHz & 25°C IN SUITABLE TEST FIXTURE

PARAMETER	UNIT	MINIMUM	NOMINAL	MAXIMUM
Quarter-wave Coupling (excluding loss)	dB	2.4	2.9	3.3
Insertion Loss	dB		0.2	0.3
Isolation	dB	20	22	
VSWR (referenced to 50 ohms)			1.1	1.2
Departure from phase quadrature between coupled and main outputs	Degrees		± 1	
Power Average*				
H Series	Watts			100
J Series	Watts			200
Power, Peak	Watts			2000
Ambient Temperature				
H Series (foil shield)	°C			105**
JB & HB Series (braided copper)	°C			150
JC & HC Series (solid copper)	°C			150
60 Hz Dielectric Breakdown Voltage between coupled pair	V rms	500	2000	
Bend Radius (with no electrical degradation)				
H Series (foil shield)	Inches	0.30		
HB Series (braided copper)	Inches	0.25		
HC Series (solid copper)	Inches	0.20		
JB Series (braided copper)	Inches	0.38		
JC Series (solid copper)	Inches	0.30		
Weight . . . H Series	Grams/Inch		0.36	
HB Series	Grams/Inch		0.62	
HC Series	Grams/Inch		0.55	
JB Series	Grams/Inch		1.30	
JC Series	Grams/Inch		1.14	

* At ambients above 55°C, derate power to 50% at 105°C

** 85°C in hard vacuum

MATERIALS

CENTER CONDUCTORS: copper wire per QQ-W-343, silver plated per QQ-S-365 Type III, Grade A, 40 micro-inch thick minimum

SHIELD CONDUCTOR:

H SERIES (FOIL TYPE): per QQ-W-343, silver plated per QQ-S-365, Type III, Grade A, 40 micro-inch thick minimum

B SERIES (BRAIDED COPPER): double braided with copper wire per QQ-W-343

C SERIES (SEAMLESS COPPER TUBE): seamless copper tubing

PRIMARY INSULATION: Polyimide film per MIL-P-46112.

INNER JACKET: Polytetraflouroethylene (PTFE) per L-P-523

OUTER JACKET:

H SERIES (FOIL TYPE): laminated Mylar/PVC per L-P-377

HB & JB SERIES (BRAIDED COPPER): Polyimide film per MIL-P-46112 with Polytetraflouroethylene (FEP) per L-P-389A binder

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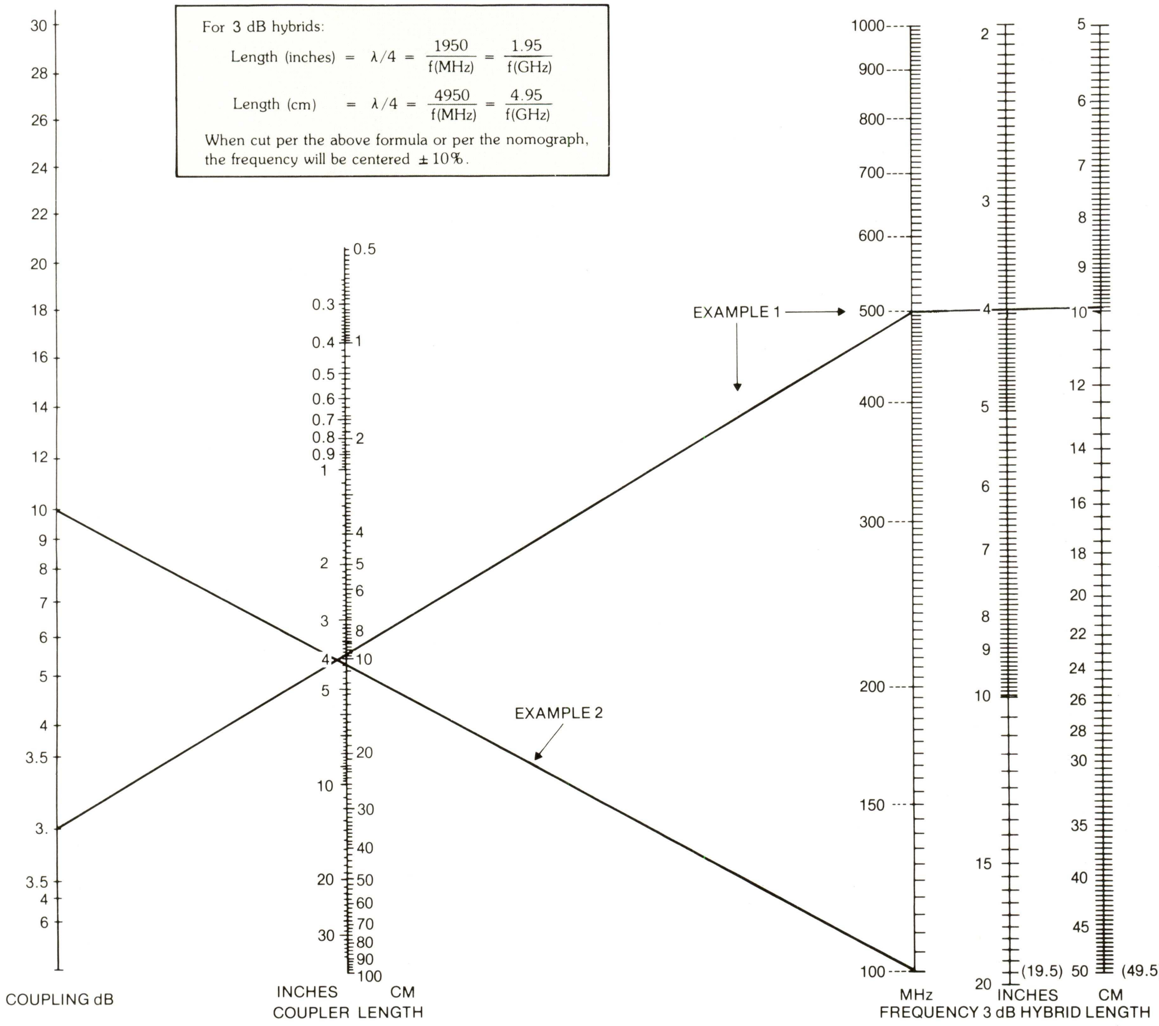
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)

For 3 dB hybrids:

$$\text{Length (inches)} = \lambda/4 = \frac{1950}{f(\text{MHz})} = \frac{1.95}{f(\text{GHz})}$$

$$\text{Length (cm)} = \lambda/4 = \frac{4950}{f(\text{MHz})} = \frac{4.95}{f(\text{GHz})}$$

When cut per the above formula or per the nomograph, the frequency will be centered ± 10%.



HOW TO DESIGN A 3-dB WIRELINE HYBRID. On the nomograph, Example 1 shows how to determine the length of a 3-dB hybrid for operation at a center frequency of 500 MHz. A horizontal line through 500 MHz intersects the 3-dB length scale at 3.9 inches (9,9 cm). This is the length, L, defined on the facing page (to the end of the Teflon dielectric). The left half of the nomograph can be used to determine coupling vs. frequency. As shown, at 500 MHz the nominal coupling is 3 dB. A straight edge passing through the 3.9 inch length and other frequencies would show that the coupling is flat within about 1 dB from 300-700 MHz with this length.

DIRECTIONAL COUPLERS. Lay a straight edge between desired coupling and center frequency. Example 2 shows that a 4.3-inch (10,9 cm) length is required for 10-dB coupling at 100 MHz.

EXTENDING THE NOMOGRAPH SCALE. Multiply the frequency scale by any convenient constant and divide the length scales by the same constant. EXAMPLE: a 3-dB coupler at 1000 MHz (twice the center frequency of Example 1) would be 1.95 inches (4,95 cm) long (half the length of Example 1).

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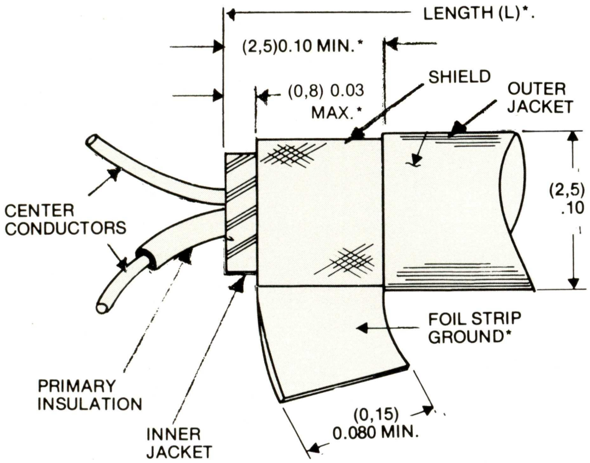
WIRELINE® QUADRATURE HYBRIDS
MECHANICAL DATA



INCHES	DIAMETER	
		M.M.
CENTER CONDUCTOR		
H, HB, HC	.012	0,31
JB, JC	.020	0,51
INNER JACKET		
H, HB, HC	.08	2,0
JB, JC	.13	3,3
OUTER JACKET		
H	.10	2,5
HB	.11	2,8
HC	.10	2,5
JB	.18	4,6
JC	.15	3,8

*APPLICABLE ONLY TO FACTORY TRIMMED PARTS

(FACTORY-TRIMMED UNITS)

WIRELINE OCTAVE-BAND 3dB HYBRIDS			LENGTH, (L) ±1%	
MODEL NUMBER (PREFIX H, HB, HC, JB, JC.)	FREQUENCY RANGE (MHz)	CENTER FREQUENCY (MHz)	(INCHES)	(MM)
50-100	50-100	75	26.00	660,4
60-120	60-120	90	21.66	550,3
70-140	70-140	105	18.57	471,7
80-160	80-160	120	16.25	412,7
90-180	90-180	135	14.44	366,8
100-200	100-200	150	13.00	330,2
110-220	110-220	165	11.81	300,1
120-240	120-240	180	10.83	275,1
130-260	130-260	195	10.00	254,0
140-280	140-280	210	9.28	235,8
150-300	150-300	225	8.66	220,1
160-320	160-320	240	8.12	206,3
170-340	170-340	255	7.64	194,2
180-360	180-360	270	7.22	183,4
190-380	190-380	285	6.84	173,7
200-400	200-400	300	6.50	165,1
210-420	210-420	315	6.19	157,2
220-440	220-440	330	5.90	150,0
230-460	230-460	345	5.65	143,5
240-480	240-480	360	5.41	137,5
250-500	250-500	375	5.20	132,0
260-520	260-520	390	5.00	127,0
270-540	270-540	405	4.81	122,2
280-560	280-560	420	4.64	117,9
290-580	290-580	435	4.48	113,8
300-600	300-600	450	4.33	110,0
310-620	310-620	465	4.19	106,5
320-640	320-640	480	4.06	103,1
330-660	330-660	495	3.98	100,0
340-680	340-680	510	3.82	97,1
350-700	350-700	525	3.71	94,3
360-720	360-720	540	3.61	91,7
370-740	370-740	555	3.51	89,2
380-760	380-760	570	3.42	86,8
390-780	390-780	585	3.33	84,6
400-800	400-800	600	3.25	82,5
410-820	410-820	615	3.17	80,5
420-840	420-840	630	3.09	78,6
430-860	430-860	645	3.02	76,7
440-880	440-880	660	2.95	75,0
450-900	450-900	675	2.88	73,3
460-920	460-920	690	2.82	71,7
470-940	470-940	705	2.76	70,2
480-960	480-960	720	2.70	68,7
490-980	490-980	735	2.65	67,3
500-1000	500-1000	750	2.60	66,0
510-1020	510-1020	765	2.54	64,7
520-1040	520-1040	780	2.50	63,5
530-1060	530-1060	795	2.45	62,3
540-1080	540-1080	810	2.40	61,1
550-1100	550-1100	825	2.36	60,0
560-1120	560-1120	840	2.32	58,9
570-1140	570-1140	855	2.28	57,9
580-1160	580-1160	870	2.24	56,9
590-1180	590-1180	885	2.20	55,9
600-1200	600-1200	900	2.16	55,0
700-1400	700-1400	1050	1.85	47,1
800-1600	800-1600	1200	1.62	41,2
900-1800	900-1800	1350	1.44	36,6
1000-2000	1000-2000	1500	1.30	33,0
1100-2200	1100-2200	1650	1.18	30,0
1200-2400	1200-2400	1800	1.08	27,5

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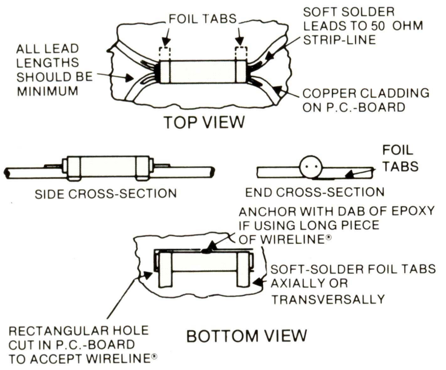
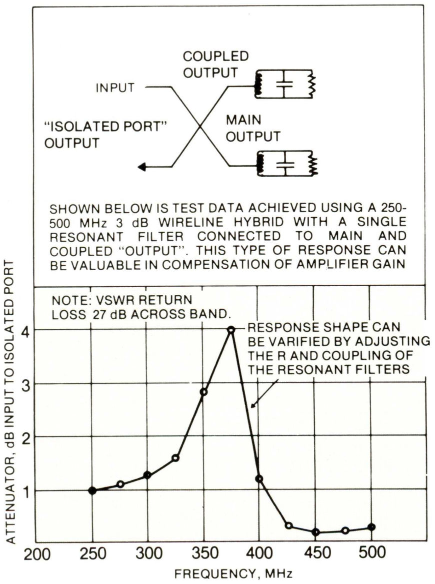
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS (cont.)
APPLICATION NOTES


FOIL TABS
SOFT SOLDER LEADS TO 50 OHM STRIP-LINE
ALL LEAD LENGTHS SHOULD BE MINIMUM
COPPER CLADDING ON P.C.-BOARD
TOP VIEW
FOIL TABS
SIDE CROSS-SECTION
END CROSS-SECTION
ANCHOR WITH DAB OF EPOXY IF USING LONG PIECE OF WIRELINE®
SOFT-SOLDER FOIL TABS AXIALLY OR TRANSVERSALLY
RECTANGULAR HOLE CUT IN P.C.-BOARD TO ACCEPT WIRELINE®
BOTTOM VIEW

SUGGESTED METHOD FOR MOUNTING WIRELINE® IN TEFLON-FIBERGLASS MICROSTRIP CIRCUITS (.031/.062 THICK), WHERE OPTIMUM HIGH FREQUENCY PERFORMANCE IS IMPORTANT.

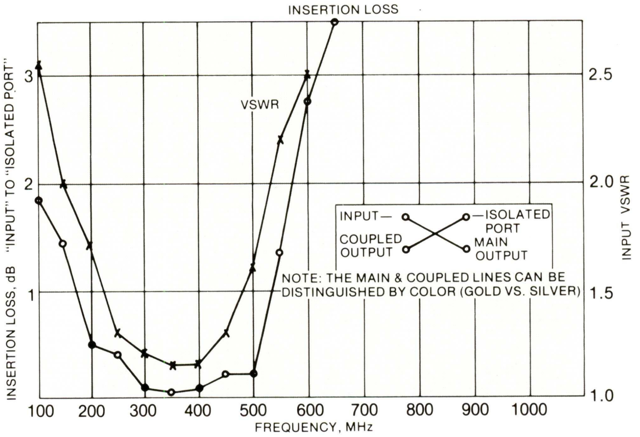


SHOWN BELOW IS TEST DATA ACHIEVED USING A 250-500 MHz 3 dB WIRELINE HYBRID WITH A SINGLE RESONANT FILTER CONNECTED TO MAIN AND COUPLED "OUTPUT". THIS TYPE OF RESPONSE CAN BE VALUABLE IN COMPENSATION OF AMPLIFIER GAIN

NOTE: VSWR RETURN LOSS 27 dB ACROSS BAND.

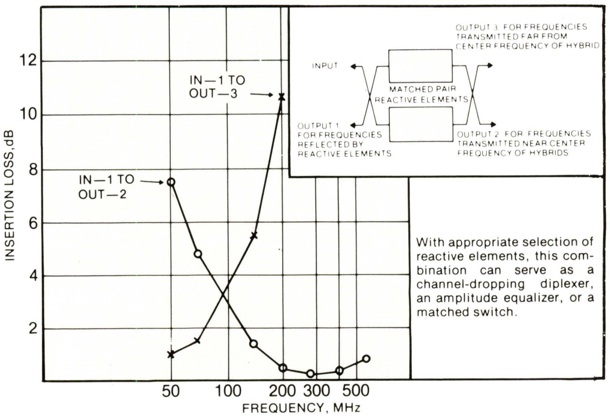
RESPONSE SHAPE CAN BE VARIFIED BY ADJUSTING THE R AND COUPLING OF THE RESONANT FILTERS

Use and performance of WIRELINE as a shaped attenuator. A 3-dB unit is necessary. Without the resistors in the filter circuits, this unit can function as a low loss group-delay compensating network for a bandpass filter.



NOTE: THE MAIN & COUPLED LINES CAN BE DISTINGUISHED BY COLOR (GOLD VS. SILVER)

Test data on a 3-dB WIRELINE coupler used as a DC block (open circuit "outputs"—no DC path—all energy reflected out isolated port). Note that the coupler must be 3 dB for a given center frequency in this application, because as the coupling departs from 3 dB, the insertion loss and VSWR increase as shown by the curves. Note that the "coupled" and "main" output leads (see diagram in box) must be the same length to their open circuits. By short-circuiting the outputs, the same performance can be achieved, with the benefit of a DC return.



With appropriate selection of reactive elements, this combination can serve as a channel-dropping diplexer, an amplitude equalizer, or a matched switch.

USE OF WIRELINE AS A DIPLEXER-DUPLEXER BUILDING BLOCK

With matched transmission lines in place of the reactive elements, the above combination can serve as a simple diplexer to separate a lower frequency signal from a higher frequency signal. In this case, the hybrids would be centered at the high frequency, and the low frequency signal would be transmitted to Output 3.

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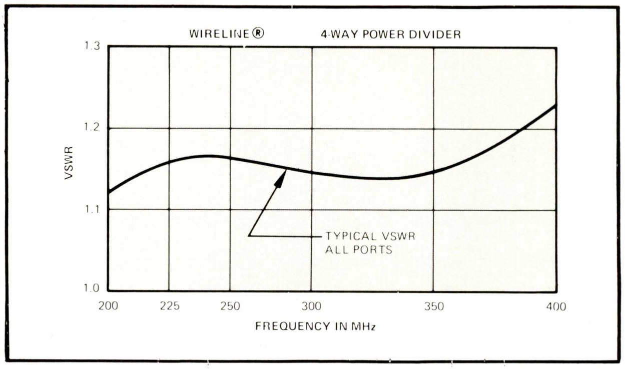
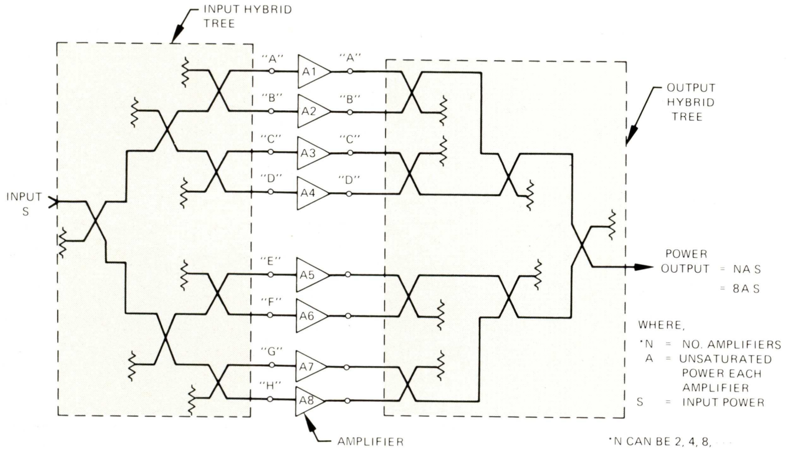
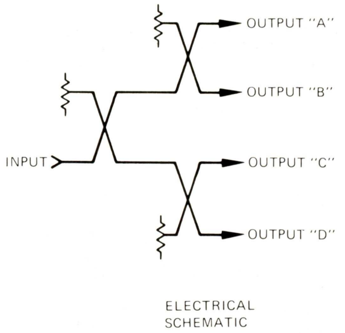
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS APPLICATION NOTES (cont.)




INPUT HYBRID
TREE
INPUT
S
"A"
"B"
"C"
"D"
"E"
"F"
"G"
"H"
A1
A2
A3
A4
A5
A6
A7
A8
AMPLIFIER
OUTPUT
HYBRID
TREE
POWER
OUTPUT = NA S
= 8A S
WHERE,
*N = NO. AMPLIFIERS
A = UNSATURATED
POWER EACH
AMPLIFIER
S = INPUT POWER
*N CAN BE 2, 4, 8,


INPUT
OUTPUT "A"
OUTPUT "B"
OUTPUT "C"
OUTPUT "D"
ELECTRICAL
SCHEMATIC

4 WAY POWER DIVIDER

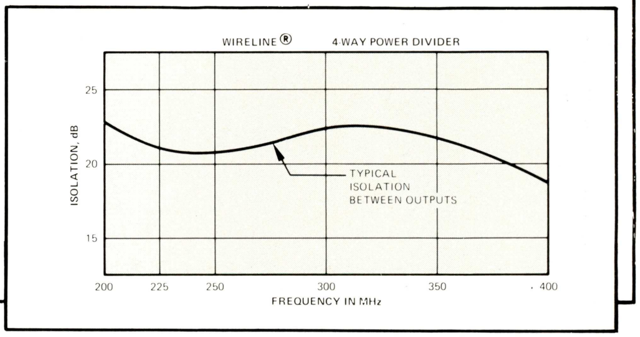
One typical application where the WIRELINE hybrids are ideal is for hybrid trees in solid state amplifiers, where the outputs of parallel amplifiers are combined to yield the arithmetic sum of their output powers.

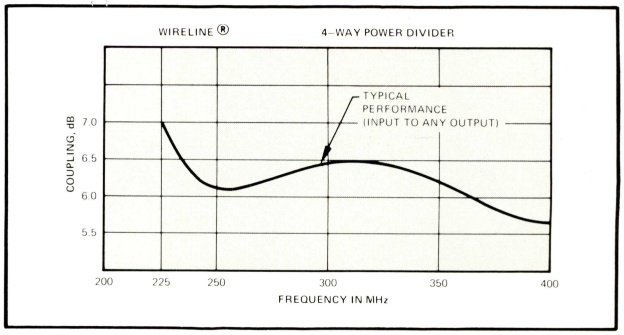
$$P_{OUT} = N \bullet P_{SAT}$$

where N is the number of amplifiers in the circuit, and P_{SAT} is the saturated power of each amplifier.

WIRELINE hybrid trees can be supplied as a package, complete with hook-up instructions for use in this type of application.

Shown on this page are diagrams and performance curves for a 4-way power divider employing three WIRELINE hybrids, covering 225-400 MHz.





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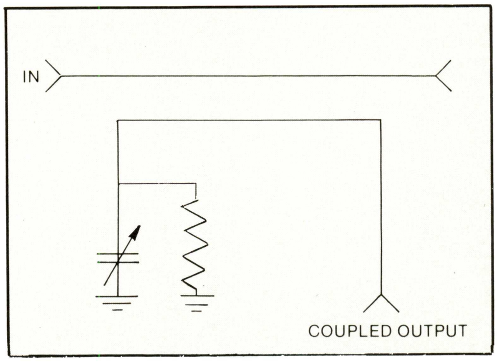
WIRELINE® QUADRATURE HYBRIDS & DIRECTIONAL COUPLERS
APPLICATION NOTES (conclusion)

VARIABLE COUPLER

A variable coupler can be constructed by terminating the normal coupler output port in a variable capacitor, in parallel with an RF termination.



POWER MONITORS

20 dB and weaker couplers designed per the nomograph have a coupling slope of 6 dB per octave. This can be compensated for by shunting the power monitor video detector with a capacitor. The value of capacitance is dependent on the video load impedance and operating frequency.

HOW TO ORDER WIRELINE®

BULK ORDERS: If you wish to order a given length of WIRELINE so that you can make your own units, simply place a B prefix before the WIRELINE style series you prefer, and specify the length in feet. (Minimum order is 10 feet.) If you order more than 50 feet, please note that we cut the WIRELINE into approximately 50-foot lengths for quality control tests prior to shipment. (5-foot lengths for BHC)

EXAMPLES:
BH-20 = 20 feet of H series (foil shield) WIRELINE
BHB-60 = 60 feet of HB series (braided copper) WIRELINE
BHC-90 = 90 feet of HC series (solid copper) WIRELINE
BJB-100 = 100 feet of JB series (high power braided) WIRELINE.
BJC-120 = 120 feet of JC series (high power solid copper) WIRELINE.

Prices are listed on the enclosed sheet. For orders above 100 feet, please contact the factory sales office. Complete trimming instructions will be shipped with your WIRELINE.

FINISHED UNITS: To order units that will be cut and trimmed by Sage, please use the model numbers shown in the table on the Mechanical Data page. Simply select the series you prefer, select your center frequency, and add the series prefix to the model number.

EXAMPLES:
H350-700 = an H series unit centered at 525 MHz
HB100-200 = an HB series unit centered at 150 MHz
HC800-1600 = an HC series unit centered at 1200 MHz
JB 1000-2000 = a JB series unit centered at 1500 MHz.
JC 1100-2200 = a JC series unit centered at 1650 MHz.

Prices are listed on the attached sheet. Please specify quantity. For prices on more than 50 units, please contact the factory sales office.

TO ORDER SPECIAL LENGTHS NOT SHOWN IN TABLE: Simply prefix your desired length (in inches)

EXAMPLE: HB-3.5

OTHER IMPEDANCE VALUES: 75-ohm WIRELINE with a braided (0.19 inch dia.) outer shield is stocked in limited quantity. Contact factory for availability.

SPECIAL REQUIREMENTS

Contact Sage Laboratories if you have special requirements such as higher power capability, impedances other than 50 ohms, etc. The following minimum information should be furnished for quotation.

Characteristic Impedance:
Quarter-wavelength coupling value:
Peak power value:
Average power value:

Cut lengths (if to be cut & stripped):

Operating Frequency:
Operating Temperature:
Style (foil, braid, or tube):
Quantity required:

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